AN INQUIRY

INTO THE CAUSES

OF THE

FRUITFULNESS AND BARRENNESS

OF

PLANTS AND TREES.

WITH PRACTICAL INSTRUCTIONS FOR THE MANAGEMENT OF GARDENS AND FARMS, AND A SYSTEM OF TRAINING FRUIT TREES, ETC., FOUNDED ON SCIENTIFIC PRINCIPLES.

ARRANGED AS A DIALOGUE.

BY

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TO THE

MOST NOBLE THE PRESIDENT AND THE MEMBERS

OF

THE BATH AND WEST OF ENGLAND

SOCIETY

FOR

THE ENCOURAGEMENT OF AGRICULTURE,

This Work,

BY THEIR OBLIGING PERMISSION AND WITH THE HIGHEST RESPECT,

IS DEDICATED BY THEIR

MOST HUMBLE AND OBEDIENT SERVANT,

THE AUTHOR.

ADVERTISEMENT.

The principal object of this work is to convey in a compact and simple form the substance of the more important parts of my former works on Horticulture and Agriculture, together with the results of much subsequent observation and experiment. My general views of the character and interest of the subject, and of the necessity of studying it systematically, are explained in the Introduction. In this place, therefore, I merely think it necessary to say, that the late Sir Humphrey Davy, who did me the honour of looking over my work on the Science of Horticulture in manuscript, declared the chemical principles laid down in it to be, in his

opinion, correct,—which I trust will be deemed a sufficient guarantee for my general scientific accuracy; and that, as regards my plans of training (which some practical gardeners have been pleased to consider altogether speculative), I shall be happy to afford to any one, who will do me the favour of inspecting my garden, the most satisfactory evidence of their feasibility; the illustrative figures being, in fact, almost all sketched from trees now under a course of training by myself.

Lyme Regis, Dorsetshire,
July 3, 1834

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PART VIII.

INTRODUCTION.

Q. I AM anxious to acquire some knowledge of gardening and farming. In what manner would you recommend me to proceed?

A. The best mode of learning gardening and farming is to study the science of those arts; that is, to acquire a knowledge of the causes of the effects you wish to produce.

Q. Do gardeners and farmers usually possess this knowledge?

A. Gardeners, or the professors of the Art of Horticulture, and Farmers, or the professors of the Art of Agriculture, certainly ought to possess it; but too many proofs exist that they do not. Those arts, as they are usually practised, consist in the regular and constant performance of a certain course of operations at certain seasons of the year, with little knowledge of, or regard to, the peculiar causes of particular effects. The results of such operations being considered to be dependent upon uncontrollable

events,—if they are favourable, all is well; if not, the failures are attributed to the intervention of some mysterious agent of nature, usually termed blight, and passively submitted to. Some accidental obstructions to the course of nature, indeed, having been observed to render certain plants and trees fruitful, those accidental obstructions have been imitated, and in some cases the imitation has succeeded. But it is well known, that, under the same apparent circumstances and under the same management, some plants and trees never fructify, whilst others are very fruitful; that some which grow luxuriantly and some which are stinted in their growth, are sterile, whilst others, in the same apparent condition, are fruitful; that some which, by putting forth blossoms, promise to produce fruit, cast their blossoms off before impregnation; whilst others, which support the blossoms during impregnation, cast the fruit off at their kerning; and that many plants and trees which produce fruit and sustain it during their kerning, are yet unable to bring it to maturity. It is therefore evident, that the causes of the barrenness and fruitfulness of plants and trees are various; consequently, that no particular operation or mode of management can be equally applicable to every case. For every particular effect, there must be some peculiar cause: before any effect can be produced, the cause must be established; before any effect can be prevented, the cause must be removed; and before we can undertake

to establish or remove a cause, we must know what it is. Now as the causes of all the effects in question are certain laws of nature established for the government of the growth and productions of plants and trees, it is obvious that, before we can exert any influence in their cultivation with any certainty of success, we must fully comprehend these laws.

It has been justly observed by an eminent modern philosopher *,—"Arts cannot be perfected, until their whole processes are laid open, and their language simplified and rendered universally intelligible. Art is the application of knowledge to a practical end. If the knowledge be merely accumulated experience, the art is empirical; but if it be experience reasoned upon, and brought under general principles, it assumes a higher character, and becomes a scientific art." Now it is very clearly demonstrable, that the arts of Horticulture and Agriculture, as they have been and still are practised and taught, are chiefly, if not wholly, grounded on accumulated experience. Neither of them, therefore, is anything more than an empirical art. Indeed, the generally prevailing opinion among gardeners and farmers, that their arts cannot be learnt from books, is of itself a clear acknowledgment, that these arts are wholly empirical, and that the general practice is not grounded on any known fixed principles; for if the

* Sir J. Herschel.

principles were understood, it would be absurd to say that they could not be set down in writing.

It is undoubtedly true, that, so long as Horticulture and Agriculture consist merely in the performance of certain mechanical operations at stated periods, the results of which are left to chance, the student can only teach himself by copying servilely what he sees done by others. But so soon as any laws of nature affecting the growth or decay of trees and vegetables are ascertained, or any general rules of training or cultivation deduced, it becomes clear to demonstration, not only that the prejudice above mentioned is unfounded, but that these arts cannot be properly and systematically taught in any other manner than by books. Of course, I am not contending that books will do every thing; since practice and theory must go hand in hand in order to produce proficiency: I merely mean to say that the most valuable part of the knowledge which a thoroughly sound and accomplished Horticulturist or Agriculturist should possess, will be found on inquiry to be of such a nature, that it not only may, but must, be got by reading.

Q. If such be the case, and the arts of Horticulture and Agriculture, as they are now followed, are merely empirical, how are we to proceed, in order to obtain such a knowledge as will enable us to establish them on the fixed principles of science, and to teach them by writing?

A. We must take a more elevated view of the

subject than has been usually taken, and give it the attention due to arts, which, when grounded on the principles of science, are capable of adding more to the happiness of mankind than almost any other arts whatever. As the author before quoted observes: "The whole tendency of empirical art is to bury itself in technicalities, and to place its pride in particular short cuts and mysteries, known only to adepts; to surprise and astonish by results, but to conceal processes. The character of science is directly the contrary: it delights to lay itself open to inquiry, and is not satisfied with its conclusions, till it can make the road to them broad and beaten; and in its applications it preserves the same character; its whole aim being to strip away all technical mystery; to illuminate every dark recess, and to gain free access to all processes, with a view to improve them on rational principles." The latter part of this extract suggests plainly enough what ought to be done; but it is to be feared that a too general disposition exists among gardeners and farmers, and also amongst their patrons, to continue in the beaten track. If we look to the proceedings of the different societies, we shall find that all their encouragement extends only to the production of the finest specimens. The mode by which these are obtained, or the causes of the effects produced, are passively permitted to remain involved in mysterious obscurity; and the means of establishing and diffusing a knowledge of the science,

are neglected or treated as of no importance. Even the terms in general use, which they are continually employing in their Reports, are so vague and indefinite, as to be in themselves quite sufficient to lead to a conclusion that the science is still in its infancy, notwithstanding all the parade of patronage which these numerous societies present. I will instance *manure* and *blight*.

The term *manure*, as it is generally applied, is so indefinite in its meaning, as to lead to opposite conclusions. Thus, if the putrescent dung of animals be buried and mixed with the soil, and then left to the natural process of decomposition, and plants are placed to grow in it, they will become rank, coarse, and diseased: such application of dung is called *manuring*. As such coarse, rank and diseased plants are seldom so fruitful or valuable as plants of more moderate growth, it is often necessary to reduce their luxuriance. The substances applied for this purpose are also called *manures;* so that both the bane and the antidote are expressed by the same term, which cannot but create confusion. If we had no other name than *food* for every substance that it is necessary occasionally to take into our stomachs, we should soon feel the inconvenience of such a limitation; for instance, if a man wanted medicine, and it was recommended to give him food, the absurdity must be seen and felt by every person. Yet not less absurd is the present use of the term

manure. As an instance of the confusion the various meaning creates, we may refer to the violent opposition in opinion among the agriculturists, occasioned by the recommendation of the use of common salt as a *manure*.

The term *blight* is equally indefinite; for being indiscriminately used to express the cause of all casual failures, it cannot convey any distinct meaning; hence, as plants, like animals, are subject to a variety of diseases, and are likewise exposed to be injured by insects and by the sudden changes of climate; if there be no other term expressive of the cause and effect of those diseases and failures than *blight*, it cannot be possible to convey a knowledge of the precise nature of any particular disease or failure, or to explain the remedy or means of prevention, by writing. It has been truly said, * "Definitions are the foundations of all science, and must explain that principle and paramount property in which its inherent qualities unite and terminate. To this property, we must assign a name, in which must be respected the analysis of language, so that the same relations may be preserved among words, which subsist among things which they denote; and the name must mark the specific difference of its object, when compared to others."

Q. But if gardeners and farmers are so ignorant of the principles of their arts, how is it that so many

* Dr. Gillies, Aristotle.

improvements have been made in the cultivation of fruits and vegetables?

A. For the most important of those improvements, we are indebted to the recent discoveries of science; but without a knowledge of science, it no doubt must frequently happen that a gardener or a farmer, by an accidental mode of management, succeeds in procuring an increased quantity of produce from his garden or farm. But, as has been remarked by a very eminent person*, "every thing which is produced by art must be grounded on some principle; and if this be not understood, it cannot be repeated with any certainty of success." Without a knowledge of the causes of the effects he wishes to produce, an artist must always be working in the dark; however successful he may be in his productions, he cannot instruct another how to produce the same effect, otherwise than by directing a mechanical imitation of his mode of practice; and this, although well adapted to one case, may be wholly inefficient in another. It therefore behoves all persons desirous of acquiring a knowledge of the best mode of managing a garden or a farm, to study the science of the arts in question; and to do this effectively, as before observed, they must divest themselves of all prejudices, and guard themselves against the influence of a bigoted assumption of authority in others, and also against being misled by the self-interested.

* Sir Joshua Reynolds.

Q. But how can any person be self-interested in obstructing the introduction of improvements in the practice of the arts of horticulture and agriculture?

A. When the science is understood, the empiric can no longer maintain his mystical importance, and the forms of plants and trees, raised and trained agreeably to the laws of nature, are so much more productive and more beautiful than those which are put under a course of training in the common way in the nursery grounds, that, were such to be had, the present cut-back and half-trained trees of the nursery-men would be wholly unsaleable.

Q. Can a tree be brought to assume a handsome and orderly figure, and be made to produce so large a crop of fruit in the same space and in so short a time, without being cut back and having the branches shortened?

A. Yes; and in producing a tree of the most perfect symmetry, and in bringing it to the most fruitful state without cutting-back or shortening the branches or stem, consists the chief value of the mode of management pointed out by the laws of nature over that which is usually followed.

Q. And has the superior beauty and efficacy of such a mode of training been established by practical demonstration?

A. The correctness of the principles, the efficiency of the mode of management, and the different methods of training, hereinafter described and elucidated by sketches, have been repeatedly estab-

lished and exemplified. But the application of the principles are so easy, and the mode of management is so simple, as to place it within the power of every gardener to put them under a course of practical demonstration with very little trouble and expense; all, therefore, who are open to conviction, may readily avail themselves of the means of forming their own judgment. But it must be understood by all, that, in making practical demonstrations, the principles and laws of nature must be clearly comprehended, and correctly and invariably adhered to and maintained; for they are so peremptory, that the most trifling deviation may impede our progress or prevent the production of the desired effect.

Q. But is a more correct mode of raising and training plants and trees, the only thing required to render them more constantly prolific?

A. No. Vegetables, like animals, require a constant and regular supply of nutriment; and the health and vigour, fruitfulness and sterility, of vegetables, are alike determined by the quantity and quality of the nutriment, and by the times and seasons of its being supplied. It is therefore necessary, in order to enable gardeners and farmers to practise their arts successfully, that they should understand the nature and properties of the various substances which supply the food of plants, and the proper times and seasons for administering it. For want of this knowledge, the common mode of applying manures is so contrary to the course of nature, that it is often

productive of more evil than good, and instead of health and fruitfulness, disease and sterility result. An acquaintance with the elementary principles and laws of nature will not only point out the proper and most improved mode of conducting this department of these arts, but it will also prove that almost all those casual failures and injuries attributed to that supposed incomprehensible agent of nature called *blight*, are produced by improper supplies of the substances intended to furnish nutriment, and are therefore the effect of causes which it is within the power of mankind to remove or prevent.

Q. But are there not cases where manuring is not required?—If so, is it not necessary to comprehend the quality of different soils, in order to understand the means of rendering them proper for producing the effects required?

A. To be able to ascertain the nature and properties of the earth, under all the various circumstances in which it is required to render it fertile, must be an object of the first importance to gardeners and farmers; and as the attention of some of the most eminent chemists of the present age has been devoted to the analysis of the different earths, as well as of vegetable and animal substances, with the view of ascertaining their influence upon the growth and productions of plants and trees, the means of acquiring this knowledge are placed within the reach of a moderate capacity, without requiring any extraordinary

exertions. To be enabled to form correct notions of the influence of the soil on vegetation, it will be necessary also to understand the use and office of the different parts of plants; and although this may require the assistance of an apparatus, which few gardeners or farmers can be expected to possess or command: yet, as the subject has commanded the attention of some of the most eminent physiologists, this also is brought within the scope of the most moderate abilities.

Q. To obtain this knowledge, then, will it be necessary to study the best authors on Chemistry and the Physiology of plants?

A. All that it can be necessary for a gardener or a farmer to understand, either of chemistry or the physiology of plants, I shall endeavour to explain. To the mere practical gardener or farmer, indeed, this knowledge may be of little importance; but, as in proportion to the accuracy and extent of their knowledge of the elementary principles and laws of nature, they are the less likely to be misled and imposed upon by fallacious theories and superstitious ignorance, it will be well for all to give it their best attention.

Q. You have not mentioned Botany. Will not some knowledge of it be necessary?

A. Not absolutely. Botany, as generally understood, comprises little more than such a knowledge of the external formation of plants as is necessary to

enable a person to arrange them in classes. Viewed in this light, it may form an agreeable amusement for the horticulturist, but it can be of little utility.

Q. As the arts of horticulture and agriculture are chiefly practised by the lower or labouring classes of mankind, does not the study of the science require a greater intellectual exertion than such artists are equal to, or than such arts deserve?

A. Certainly not; and although the practice of those arts has been chiefly confined to the lower orders, it will be shown, that they are not less deserving the attention and study of the higher classes than any other art whatever. Sir Humphrey Davy justly observes, "the attention of the labourer will be more minute, and he will exert himself more for improvement, when he is certain he cannot deceive his employer, and has a conviction of the extent of his knowledge. Ignorance in the possessor of an estate, of the manner in which it ought to be treated, generally leads either to inattention or injudicious practice in the bailiff or gardener." Nor is it merely as regards immediate profit, that the pursuits in question may be advantageously followed by the higher classes of society. In the course of the following chapters it will appear, that no sciences embrace more of the truly dignified objects of natural philosophy, nor afford a wider field for the exertion of the intellectual faculties, than

the sciences of horticulture and agriculture; whilst the arts, by affording an unbroken succession of objects of interest and anticipation to the mind, as well as a constant inducement to exercise in the open air, must obviously contribute largely to the health and happiness of those who cultivate them.

ERRATA.

Page 41, line 1, insert *and from* after *to*.
— 64, — 18, for *masses* read *matters*.
— 66, — 9, insert *difference of the* instead of *differing*.
— 98, — 12, insert *may* before *run away*.
— 130, — 29, for *trees* read *leaves*.
— 134, — 27, insert *will* after *it*.
— 166, — 25, dele *daily*.
— 177, — 13, for *whilst* read *as*.
— 286, — 16, for *agreeable* read *agreeably*.

PART I.

EXPOSITION OF THE PRINCIPLES OF CHEMISTRY.

NECESSARY TO BE UNDERSTOOD,

TO ASCERTAIN

THE ELEMENTS AND PRINCIPLES OF VEGETATION.

Q. Is it then requisite to study chemistry to acquire a knowledge of the principles of gardening? If so, will this not require greater abilities, and demand more attention, than can be expected in a gardener?

A. It is not absolutely necessary to enter deeply into the study of chemistry, to qualify a person to cultivate a garden; but it is well known that the fertile powers of lands are liable to be exhausted; and consequently, to preserve them in a prolific state, they will require to be replenished. This replenishing is generally effected by what is called manuring; but manure is a term that cannot well be defined, nor can its nature and effects be described or understood, without some knowledge of chemistry: for as the

application of substances that are calculated to produce directly opposite effects on land is called manuring; if the nature and composition of the substance which is called manure, and the nature and composition of the soil to which it is applied, be not understood, the directing land to be manured can lead to no certainty of effect; but that which may prove beneficial in one case may be detrimental in another. It must therefore be evident, that unless the elements of which the earth is composed, as well as those principles and laws of nature which regulate and determine the production and adaptation of the fertilising principle, be understood, a knowledge of the causes of those effects which it is desirable to produce by the various operations of gardening cannot be obtained. Then as this knowledge is so essential, and may be acquired by a little attention to what is described to be the result of the practical experiments of many chemists most eminent for talents and scientific knowledge, the making ourselves acquainted with these results must be time and attention well bestowed; and although chemistry, as it was pursued and practised in former times, was perhaps justly considered to be an abstruse and difficult art, it may be readily comprehended and easily practised, as now established.

Q. Has any regular course of chemical investigation of the different soils and manures been undertaken, and the results described, by men competent to the task, with the particular view of establishing the cultivation of vegetables on the principles of science?

A. Yes. Many of the most eminent chemists have given their attention to this subject, and many elaborate works have been published on it; but their attention having been directed more to the minutiæ of the proportion of the various compound bodies which form the soil, than to the existence and influence of particular elementary principles, or to the processes of nature, which determine their combination or separation; the labours of these philosophers have been more productive of speculative theories than tending towards the establishment of science.

Q. To what object then must we first direct our attention, to make the study of chemistry beneficial in the practice of horticulture?

A. It is well known that if the seeds of vegetables be placed in the earth, under proper circumstances, they soon vegetate and produce young plants; that such plants grow and increase in size; and that in some situations, and in some parts of the earth, plants attain a larger growth or size, and are more prolific, than in others. It is also well known that land which is prolific for a season or two, will by the repeated loss or removal from it of its vegetable produce, if no other vegetable or animal matter be supplied in its stead, become exhausted of its principles of fertility. Then the first objects of horticulture must be to make sterile lands prolific, and to restore the principles of fertility when exhausted: and as fertility and sterility are the effects of certain causes, we must ascertain what those causes are;

that is, as those causes are certain elementary principles brought into action and rest, and to a separate or combined existence, by certain laws of nature, we must ascertain what those elementary principles are, of which vegetables and animals are composed, and also what those are of which the different soils are composed, as well as the laws of nature which determine their composition; and then, by observing analogies and submitting our deductions to the test of repeated experiment, we may acquire a knowledge of those truths which constitute science. The analysis, or the operation necessary to ascertain the elementary principles of which vegetables are composed, has been performed by many eminent chemists, and all agree in concluding that vegetables are compounded of four simple or elementary principles only, which are oxygen, hydrogen, carbon, and earth. The earths indeed are not simple bodies, but formed of various compound substances; but as it regards vegetation, four of these compounds only need be distinguished, and each of these may be considered as an elementary substance. This will be explained hereafter.

Q. How are substances proved to be elementary or simple bodies?

A. When a chemist has exerted all the means in his power to decompose and divide a body into two or more elements, and cannot proceed further, we may justly conclude that such a body is itself an element or simple substance. Thus, in former

times, earth, water, and air, were considered to be elementary substances or simple bodies, because the means of decomposing them were not then known; but such means having been found in later times, it has been proved that they are compounds, and formed of various elementary or primitive substances.

Q. Are the means employed by chemists to effect the decomposition of bodies the same as those adopted by nature for such purposes?

A. Certainly. All that chemists can do is to ascertain the laws and principles of nature; and how to protect and sustain her operations by bringing such substances into contact with each other, or such principles into action, as are required to produce certain effects. Thus, it is ordained by nature that certain elementary substances shall possess a certain affinity for each other; so that when two such substances are placed together under certain circumstances, they shall blend or unite together, and form a compound substance. Hence when a third substance exists, having a greater affinity for one of the elements of a compound substance than for that to which it is united, and an antipathy to the other, and this third substance is placed in contact with the compound substance, and under the influence of a certain degree of heat, it will unite itself to the one for which it has an affinity, and form a fresh compound, and repel or leave the other free and at liberty to exist separately or to unite itself to any other element that may be present for which it may have a greater affinity.

Q. But does not the composition and decomposition of natural bodies spontaneously take place, when left to themselves? and if so, what is the principle or power which incites them to action?

A. Whenever animal or vegetable matter that is deprived of life is left to itself, decomposition spontaneously takes place; and the principle of action, or that which commences or completes the decomposition, is caloric or heat. From a number of demonstrative experiments by the most eminent chemists, it is concluded by some that all substances, both animate and inanimate, contain within themselves a certain portion of caloric, either in an active or a latent state, which is capable of being brought into action, and raised, and concentrated, even to the power and existence of fire, by a variety of natural means, such as by pressure, by friction, by percussion, and by the concentration of the rays of the sun. By others it is averred that all substances are composed of atoms, and that heat is the result of those atoms being put into action by pressure, friction, &c. But whatever may be this process of nature, it is a knowledge of the elementary substances, the degrees of affinity and aversion which they have for each other, the circumstances which most favour their union and disunion, and the best and most effectual means of exciting and applying heat, that constitutes the science of chemistry.

Q. How are the degrees of affinity which those elementary substances have for each other to be

ascertained? and what are the means to be adopted to analyse vegetable matter, the earth, &c.? Will it not be necessary to understand this?

A. Without entering into a detail of minute chemical affinities, proportions, and distinctions, we may avail ourselves of the knowledge described by many eminent authors, to inform ourselves of such of the most prominent and essential elements and principles as will enable us to exert the utmost influence over the operations of nature in the department of vegetation. For, as already observed, the analysis of the earth, of air, of water, and of animal and vegetable substances, has been performed by many eminent practical chemists; and what they all agree in describing to be the results of demonstrative experiment we may confide in as true; at any rate until, by the comparative results of actual practice, we have sufficient evidence to warrant our doubting them. Considering, therefore, that a more minute description of chemical principles, and of the different modes of operating, would be digressing widely and uselessly from our main object, we must refer those who wish to enter more fully and particularly into the science and practice of chemistry, to those modern authors whose works relate to this subject only; and by modern must be understood such as have been published within the last thirty years, for previously to this period the elements which compose the air and water were not understood.

Q. What are the most prominent and essential

elements and principles necessary to support vegetation, that are made known by chemistry?

A. As before observed, a plant being established in the earth, grows and performs its functions conformably to the order of nature, as long as it is supplied with the required nutriment; and it is found that some parts of the earth afford this nutriment in plenty, while other parts afford but a scanty supply, and others, none at all. It is also found that even that part of the land which is replete with nourishment is exhaustible. The grand object then must be to ascertain what this exhaustible substance is, or what constitutes the nutritive principle or the pabulum or food of plants. It is found by experience that water is a necessary ingredient in the nutriment of plants, and the only medium by which it can be administered; and that a continued supply of fresh water is needful to their existence. It is also proved that animal matter affords the nutritive principle required by vegetables: and that animals are in many respects essential to sustain the vegetable world. It behoves us, then, first to ascertain what the elementary principles are which enter into the composition of air, earth, and water; as well as those which enter into the composition of animals and vegetables: and next, to ascertain the laws of nature, which render the one dependent upon the other, regulate and determine their construction, and support their existence.

Q. Then the elements of which vegetables are

compounded being as described; what are those which constitute animals, the air, and the water?

A. Animals are formed of oxygen, hydrogen, nitrogen, carbon, and earth. Atmospheric air is formed of oxygen and nitrogen, in certain proportions, rendered aerial by the expansive power of heat or caloric; it also generally holds in combination a small portion of carbonic acid gas, or fixed air. Water is formed of hydrogen and oxygen, in certain proportions; and in its common state it always holds a certain portion of earth, and sometimes of carbon, in solution.

Q. In what form do these elementary or primitive substances exist, and how are they to be known?

A. Oxygen, hydrogen, and nitrogen are aerial substances, which, when in a state of separate existence, are termed gases, and, like the air we breathe, are invisible, and can only be known by their effects; the names or designations which are given to them are derived from the Greek or Latin languages, and express, or allude to, their nature and properties. Thus it is found that by the affinity which certain substances have for oxygen, this element, under certain circumstances, is united to them in such a quantity as to convert them into acids; hence oxygen is considered to be the acidifying principle, or generator of acids, which the term implies. Oxygen is also the vital air of life, as without it neither animals nor plants can live; it is also a general principle of combustion, as without it fire cannot exist.

Hydrogen, the basis of inflammable air, is a component part of water, as the term implies; and it is the lightest of all ponderable things. It is hydrogen gas which, when burnt in contact with oxygen, produces flame, and gives the brilliant gas-light. It is also this gas with which air-balloons are filled; and which, from being so much lighter than atmospheric air, enables them to ascend through it.

Nitrogen is one of the elements of nitre; it is also called azote, which implies destructive of life. It is the opposite in nature to oxygen, that is, it is incapable of supporting combustion or animal life.

Carbon, which is derived from the Latin of coal, is clearly proved to be an elementary substance; although, like the aerial elements just described, it can only be generally known by its effects: for from the great affinity it has for oxygen, and also for hydrogen, metallic substances, and the earths, it cannot be obtained in a pure and free state but with great difficulty. The diamond, indeed, is considered to be pure carbon in a state of crystallisation, and is the only substance in which carbon is known naturally to exist in a separate state. The purest state in which carbon can be obtained and exhibited, by the common processes of nature and art, is that in which it is combined with oxygen; and those two elements, combined in different proportions, form three distinct compounds, viz. carbonic acid gas, or fixed air, which is composed of 18 parts of carbon and 82 parts of oxygen in every 100 parts; carbonic oxyde, which is

composed of 40 parts carbon, and 60 parts oxygen; and carbonous oxyde, which is common charcoal, and is composed of 64 parts carbon and 36 parts of oxygen. Carbon also unites with hydrogen, and thus forms carburetted hydrogen gas, which is carbon dissolved in, or combined with, hydrogen—in this state it always produces a fetid smell—and hydro-carbonate, which is carbon combined with hydrogen in a less quantity than is required to convert it into gas. The mode of obtaining pure carbon, as described by Sir Humphry Davy, is by burning pure spirits of wine in a glass tube, by which the gaseous part will be dissipated and the carbon left; and as spirits of wine is one of the most limpid and volatile liquids, this shows how completely carbon is dissolved or divided, and held in perfect combination, in the purest liquids.

Q. On a comparison of those different compounds, and of the nature and properties of the elements or primitive substances, what are we to conclude forms the pabulum or needful element for the nutriment and sustenance of plants?

A. It being found that carbon does not form a necessary and component part of the earth, and is not at all times contained, in the earth, nor in the water, nor in the air; but that it is contained in, and forms a component and large part of, all vegetable and animal matter: it being proved also, that earth, air, and water, divested of carbon, will not sustain plants; and that animal and vegetable matters, being added

to the earth and water, and brought in contact with the roots of plants, imparts to them the nutritive principle—we may conclude that carbon is the pabulum or needful element; and that as it exists in greater or less proportion in the soil, and as it is acted upon more or less by the gaseous elements, it is this element which occasions the variation in the productive powers of the soil.

Q. As it appears then that all the objects of the created world are formed by five or six elements, combined in different proportions, how, and by what means, are those different proportions ascertained and determined? how, too, are the different elements separated and divided, and brought together and re-combined after separation?

A. All these things are regulated and determined by certain immutable laws of nature, by which the powers of mankind are also limited and determined: thus, by the aid of chemistry, we can bring carbon and oxygen into contact, and induce those elements to unite in such proportions as to form carbonic acid gas, carbonic oxide, and carbonous oxide; but no means are at present known of combining carbon and oxygen in any other definite proportions, or of forming by those elements any other distinct compound.

Q. Can those laws and principles of nature be understood and defined, so as to enable us to comprehend the means by which the created world can be sustained and continued by so few elementary

substances—and the proportions so accurately determined and furnished?

A. Yes. As we have before observed, the grand principle of action, or the impelling power, is caloric or heat; which, exclusive of its existing either in an active or in a latent state, or being capable of being excited, in all bodies, is also produced by the sun and exhibited in electric fluid; by the agency of this (which, although we cannot create, we can at all times command to a great extent), we can demonstrate that certain effects are produced by certain causes; and we are thereby justified in making the following conclusions.

As it is found that by the natural affinity of certain elementary substances to one another, all animal and vegetable substances are compounded, it may be justly concluded that in the general composition and continuation of the world, its elementary matter is indestructible, and that the animal and vegetable parts are continued and sustained by translocation only; in other words, that the general process of nature is carried on by making death and decomposition furnish the means of transformation, or of producing a new composition; to this end, animals and vegetables are made dependent upon each other, and compelled to act conjointly in support of universal existence and order. Thus animals are endowed with the powers of destroying, masticating, digesting, and decomposing the substances both of animals and vegetables, and may therefore be considered as forming the superior part

of the creation; and as vegetables, from their peculiar formation, cannot take anything into their bodies but in a state of liquid, or so minutely divided as to be combined with water, animals are necessarily made the agents for depriving the solid substances of life, and of reducing them to a state to be decomposed, and are thus instrumental in preparing the nutriment or food of vegetables: for by destroying and devouring both animals and vegetables, they facilitate the decomposition and reduction of those substances to a state of solution; and vegetables, notwithstanding their delicate formation, are peculiarly designed to perform an equally important part in the grand process of nature; for, acting in unison with animals, they assist in sustaining and continuing the animated world, by bringing the divided substances again into action and union, and of thus again restoring them to a state of combined existence.

Q. What are the means established by nature for the decomposition of animal and vegetable substances? and by what processes are the various changes effected?

A. When animals and vegetables are deprived of life, and left to natural decay, they are decomposed by a disturbance or agitation of the elementary principles, which spontaneously takes place: by this process, which is called fermentation, carbon and earth are deposited, and the oxygen, hydrogen, and nitrogen are disposed of by forming carbonic acid gas and carbonous oxyde; a part of the oxygen uniting to nitrogen and potash is

converted into nitre; under certain circumstances carbon is also united to hydrogen, and, according to its proportions, converted into carburetted hydrogen gas, or hydro-carbonate; and sometimes the hydrogen and nitrogen are emitted separately as gases, or unite and form ammonia. It is also proved that plants possess the power of decomposing water; and, for the purpose of converting it into their own various substances, of retaining and applying the hydrogen, carbon and earth contained in it, and also a part of the oxygen; and of expelling or emitting the superfluous oxygen as excrementitious; and these elements being separated, are again combined by the various processes of nature. Thus, by the combustion of electricity, the oxygen gas emitted by vegetables, and the hydrogen gas emitted by putrescent animal and vegetable matter, are united, and form water. By natural affinity, oxygen gas is united with the nitrogen gas thrown off by the respiration of animals and otherwise, thus forming atmospheric air; and carbonic acid gas, from its density, sinks below the atmospheric air, and is readily brought in contact with calcareous, carbonaceous, and metallic substances on and in the earth, and also with water; by these it is decomposed or absorbed, and probably converted into the food of plants.

Q. If such, then, be the process by which the animal and vegetable worlds are sustained and continued, what influence do we possess over the workings

of nature, and in what manner can such influence be best exerted?

A. As we know that certain elements enter into the composition of plants, we may justly conclude that, to produce plants in a certain state and condition, those elements must be provided and combined, and brought into contact with the roots of plants; and as we know the elements of which animals are composed, and the powers which animals possess of facilitating the decomposition of vegetable and animal matter and of thus liberating and furnishing the elements required by vegetables, we must inquire into the means of combining those animal and vegetable powers, and of ascertaining the proportions of the different elements contained in certain vegetable and animal substances, as well as into the circumstances under which they are combined and made to produce certain effects. For this purpose, we must first investigate and ascertain the nature and properties of the earth, and its peculiar influence on vegetation; which will be attempted in the next chapter.

PART II.

OF THE NATURE AND COMPOSITION OF THE EARTH, AS RELATES TO VEGETATION.

Q. Is not the growth and the production of vegetables dependent upon the soil? and if so, what forms the soil?

A. Certainly: the vegetative part of the earth is called the soil; but some soils, or some parts of the earth, are more prolific in vegetation than others; and as this must be the effect of some peculiar cause, we must endeavour to ascertain such cause; for unless this be understood, we cannot form correct notions of what forms a fertile or a sterile soil. As plants derive their sustenance from the soil, it is very evident that the cause of fertility must exist or be established in the earth; and we have shown that the most simple and certain means of discovering the fertilising principle of the soil, must be to ascertain the elements of which those parts of the earth are formed, and the principles or laws of nature which

determine and influence their combination in the production and sustenance of vegetables. A knowledge of the principles of fertility having always been the grand desideratum of the professors of horticulture and agriculture; the earth has been submitted to chemical investigation and analysis by many eminent chemists, and the results prove that simple earth is chiefly formed of the oxides of metals; that is, of metallic substances combined with oxygen. But as it does not appear that the vegetating qualities of the earth depend much on the peculiar metallic nature of those oxides, it has not been decomposed with a view to ascertain the exact proportions of those elements of its composition, which consequently are not known. It is very evident, however, that iron is the prevailing substance in all fertile earths. and it having been proved that the earth in which vegetables grow generally exists in three distinct states or substances, differing widely in their nature and properties; and that the influence of the earth on vegetation is determined by the proportion of each of those substances contained in its composition, we may consider them as simple bodies or elementary substances, so far, at any rate, as they are concerned in upholding vegetation. They are distinguished by the following names: viz. argile, or clay; silex, or flint; and limestone, or those substances which by calcination form lime. It having been proved that these substances, whether separate or

combined, with the addition of water only, are not capable of sustaining vegetables in vigorous health and proficiency, it must be concluded, that some other substance must be combined with the earth to form the pabulum or the nutritive principle of plants; consequently that the earth of itself forms only a laboratory to prepare, and a medium to dispense, this pabulum or nutritive principle for plants, and a lodging or bed for the roots to range, feed, and repose in. To supply the earth with the requisite power to sustain the vegetable world, or to furnish it with the nutritive principle, it has been shown, that the all-wise and benevolent Author of Nature has created a fourth substance, called carbon; which substance possesses such extraordinary qualities as to be capable of uniting itself to, and of being diffused throughout, almost all the substances, both animate and inanimate, that exist in the world. This union and diffusion is effected by an infinite variety of means. To make the requisite collection and combination of carbon, and to reduce it to the state necessary to sustain the vegetable world, the united action of animals and vegetables is rendered necessary; and as carbon is an essential ingredient in the composition and sustenance of both animals and vegetables, it must form a great part of the residuum of their decomposition. It is the result of the decomposition of animal and vegetable matter, of which the oxycarbonate and hydrocarbonate are

formed, which is called mould; this is the state or preparation to which carbon is reduced, and in which it furnishes the most efficient nutriment for plants. By the indefinable workings of nature, the three first described elementary substances of the earth are pulverised and mixed together, and such compound or mixture forms what is called loam; and when loam is brought on the surface of the earth, and combined and mixed with mould, it forms what is called the soil.

Q. Then, as the soil is compounded of such a variety of substances; have the proportions of those substances any great influence in determining its powers of production?

A. Yes: according to the proportion of the different substances, which enter into the composition of the soil, will it vary in its productions; the influence which those productions have on vegetation, will be more fully explained, when the nature and the use of the roots and the food of plants are described. Soils, as they affect vegetation generally, may be considered as possessing two distinct properties only, which are the chemical and mechanical; but in their general state they are distinguished and divided into four classes, and designated as follows: that, wherein clay forms the greatest proportion, is called an argillaceous soil; that in which silex or flint sand prevails, is called a siliceous soil; when pulverised limestone and magnesia prepon-

derate, it is called a calcareous soil; and that which is formed principally of decayed animal and vegetable matter or mould, is called a carbonaceous soil.

Q. As the soil is so variable a composition, how is it made and brought so generally to cover the surface of the earth without the intervention of mankind? Are the means by which nature accomplishes this known and visible?

A. It is effected chiefly by the earth worms, and these little creatures may be considered to be nature's best cultivators of the earth. A portion of carbonaceous matter appears to be a necessary ingredient in their food, which is principally supplied on the surface, and as they have no other means of making their way through the earth, which is the compartment of the world appropriated for their occupation, than by eating the substance necessary to be removed to form their passage; they carry this with them to the surface, and in their descent they leave the masticated substance there; and thus, by their continued workings, the surface of the earth is covered by a finely-divided soil.

Q. But, as to the earth-worms being nature's best cultivators, do they not prey on the roots and other parts of vegetables, and injure and destroy them?

A. No: they never eat, nor even bite, nor in any manner injure, living plants; but sometimes, when plants are slightly fixed in the earth, they will draw them out, and carry them like dead vegetables to their holes: this is the only mischief they ever

occasion. By their working through the earth, the worms also produce another important and beneficial effect; their passages afford efficient and ready conduits for the water, which distributes itself through them.

Q. What are the chemical properties of the soil? and how are these found to be operative?

A. The calcareous earths, which are composed chiefly of pulverised limestone, gypsum, or magnesia, or broken shells of fish, and which, indeed, comprise all those substances that by the operation of fire, or by the process which is called calcination, form lime, are absorbent and antiputrescent and possess peculiar affinities for peculiar substances; thus they operate powerfully on mineral and vegetable matter in the disengagement and combination of the elements and principles requisite to form the nutriment of plants.

Q. What are the mechanical properties? and how are these brought into action and operation?

A. As a plant increases in size, it requires an increased supply of nourishment; for the purpose of collecting and appropriating its nutriment, the roots are continually increasing and extending themselves, both in length and bulk, by swelling and pushing out numerous small points on all sides; therefore, as an open and easily divisible soil offers less obstruction to the advance of the roots, such a soil is more genial to the regular growth of vegetables than that which is close and tenacious. It is also

proved, as will be hereafter more fully explained, that water is not only an essential ingredient in the nourishment of plants, but that to sustain plants in health and vigour, such water must be kept in constant motion among the roots, as stagnant water is obnoxious and unwholesome to them. As in the beautiful and all-perfect system of vegetation, established by nature, nothing is left unprovided for, this requisite motion is created and sustained by the principles of gravitation, capillary attraction, and evaporation ; that is to say, when water is supplied on the surface of the soil, by rain or otherwise, it is by the operation of gravitation made to sink and percolate through the earth ; and when by the operation of the sun, the water on and near the surface of the earth is rarified and evaporated, fresh water is by capillary attraction brought from below, and raised to the surface, to supply the place of that which is carried off. As during these operations, the water in its passage, both upwards and downwards, passes by, and is brought in contact with the roots; these abstract and absorb what is required by the plant. It is also requisite to sustain vegetation, that the soil, and particularly that near the surface, be sufficiently open to allow a free admission and escape to the air; a friable and easily divisible soil, therefore, or that which is so mechanically formed as to sustain those operations of nature, must be the best adapted to support vegetables in health and vigour.

Q. How is it demonstrated that such motion and

supply of fresh water to the roots of plants is thus kept up in nature?

A. If you pour a sufficient quantity of water into a common flower-pot filled with earth, a great part of it will sink and percolate, or pass through the earth into the pan underneath: this motion is occasioned by gravitation; when the pot is exposed to the sun, the water in the earth will evaporate, and the water in the pan again be drawn up into the pot; this action is promoted and supported by what is called capillary attraction. The quantity of water consumed by plants is so great, that some plants, as has been proved by experiment, consume a quantity equal to their own weight in twenty-four hours; and, exclusive of the quantity of water consumed by plants, it has been proved, by covering a certain space of the surface of the earth with a glass receiver, and collecting and condensing the vapour, that the quantity raised by evaporation is equal to 1,600 gallons of water from an acre of land during a twelve hours' day in the summer. It is therefore obvious, that as so much water is disposed of by the consumption of plants and carried off from the surface and upper stratum of the earth by evaporation, were it not for the effect of capillary attraction, which raises the water from the bosom of the earth, vegetation must be obstructed and destroyed for want of nourishment during the long intervals of dry weather which occur in the summer season.

Q. How does it appear, that a free admission

and escape for the air, to the roots of plants, is required?

A. It has been proved by planting seeds in the earth, moistened with water and placed in bottles closely corked, that in this state, they will not vegetate: and it is concluded, that it is for want of oxygen, or a supply of fresh air. When the roots of plants have been cut, or torn off, in planting, or when cuttings of the branches are planted for rooting, they strike root much more readily, and with greater certainty, in an open and sandy, or porous soil, than in that which is closer and tenacious: which shows, that oxygen or fresh air is also requisite to give activity and vigour to the roots. Further, if after seeds are sown on a stiff loam, or clay soil, water be poured on it, in sufficient quantity to reduce it to mud, it will, when dry, bake on the surface, and become impervious to the air; and whilst in this state, the seeds will not grow in it.

Q. What description of soil is the most open and porous, and the best calculated to support the process of capillary attraction?

A. Calcareous sandy soils are the most open and divisible, and, in general, the best calculated to support capillary attraction: therefore, soils composed of a mixture of calcareous sand, carbonaceous matter, and argillaceous earth, in due proportion, are found to be the most productive for general cultivation.

Q. You say calcareous sand; but will not siliceous sand do as well?

A. No: siliceous sand or flint gravel possesses a smooth and polished surface, and is not absorbent; consequently, when argile or clay is brought into contact with it, it adheres to the clay so closely, as to form a mass almost as impervious to water, as clay itself; it is this sort of mixture which forms what is called stiff loam or black earth.

Q. How is the quality of a soil, or the proportion of the elements of its composition, to be ascertained?

A. If you take up a small quantity of earth, it may be examined, and its texture or general quality ascertained with sufficient accuracy for the purposes of horticulture, by pressing it between the fingers. If it is mere sand, or such soil as will not adhere together when dry, it will be too open, and will not retain sufficient moisture to nourish plants; but if it adheres together when dry, and yet gives way readily to pressure, if it crumbles and divides easily, and appears mellow to the touch when wet, it will prove to be of a good texture, and sufficiently open to sustain vegetation in health and vigour. If it is tenacious, adheres together in compact lumps when dry, and, when wet, forms a soapy adhesive mass, it will be too retentive and too impenetrable either for the roots of plants, or for water: which is always found to be the case, when soils are formed chiefly of clay, or of clay and siliceous sand. Hence brick earths are always very uncertain in their produce, and difficult and expensive to work. The quantity of carbonaceous matter contained in the soil is indi-

cated, in a great measure, by its colour, this being always of a black or dark brown colour; whilst the native soils are of a whitish, blue, yellow, or fox colour. The prevalence, more or less, of black or dark brown colour, will show the proportion of carbonaceous matter. Soils that are formed wholly of vegetable matter, which constitute what is called bog earth, or of vegetable matter and sand, which constitute what is called a peat soil, are generally black: these, although of an open and spongy texture, are, when dry, very light, and repulsive of water; but when saturated with water, they are very retentive; and therefore altogether ill adapted to sustain capillary attraction; these consequently are found to be sterile and unproductive of fruits and seeds.

Q. Is the colour of the soil indicative of any other peculiar qualities, or productive of any other important effects on vegetation?

A. Yes: a yellow or foxy colour shows it to be strongly impregnated with sulphuretted iron, and in a state which is detrimental to vegetation; the colour of the soil also determines its comparative quality of being hot or cold. It is found that a black or dark brown soil, exposed to the sun for a given time, will acquire from eight to ten degrees of heat, by Fahrenheit's thermometer more than a white soil under the same circumstances: this arises from black being a rapid conductor of heat, and white a slow conductor: for as black readily absorbs heat,

it must as readily part with it again; and as white absorbs heat but slowly, it parts with it but slowly. Again, as black soils absorb heat more readily than white, water is more readily evaporated, and capillary attraction better sustained: consequently black and dark-coloured soils are generally more productive than those of a light colour.

Q. Does the comparative degree of heat or cold materially affect vegetables in their growth and produce?

A. A high degree of heat not only increases the growth of a plant, by giving a more early and rapid motion to the sap, but it brings it more early into bloom, and its seeds and fruits more early to maturity. By increasing the evaporation of water from the surface of the soil, it also increases the supply of fresh water to the roots by capillary attraction; thus an increased quantity of food is furnished, to promote and sustain the additional growth of plants.

Q. It appears, then, that neither of the primitive earths are of themselves properly adapted to vegetation, but that a mixture of two or more of them forms the most productive soil?

A. Undoubtedly: an admixture of sand and clay forms what is called loam; and loams are better adapted to vegetation than either clay or sand alone; but, as before observed, the nature of the sand which is blended with the clay determines its quality. If it be calcareous sand, or limestone pulverised, it

will work well, but if it be siliceous or flinty, it will be difficult to work; for, as before observed, the clay will adhere so closely to the polished surface of the siliceous sand or gravel, as to be almost as tenacious as clay. And soils that work well, that is, all those which are friable and readily pulverised when turned up by the spade or the plough, are generally the most prolific.

Q. The vegetative soil then, being that which generally covers the surface of the earth, has it been ascertained what quantity or depth of soil is best adapted for a garden?

A. For the production of seeds, fruits, and flowers, and indeed for the purposes of gardening generally, from six to twelve inches of vegetative soil will be found sufficient in every respect; for when roots delve below this depth, although the plants and trees grow large and luxuriant, they are generally diseased and unproductive. But this must, in a great measure, depend upon the nature of the subsoil, or the foundation upon which the vegetative soil rests; for this has great influence in determining the health and prolificacy of plants, inasmuch as it permits or obstructs the percolation and capillary attraction of water. If the vegetative soil rests on loose gravel, or coarse sand, it will be subject to failures, from long-continued dry weather; and if the subsoil be close and impervious, the water will stagnate about the roots, and produce disease, or rot them.

Q. But whether the subsoil be clay or loose gravel,

will not a great depth of vegetative soil lessen, if not prevent, the injuries arising from an excess of either, by retaining the moisture a greater length of time in the one, and preventing the roots from embedding themselves in the other?

A. It may in some degree operate in this manner, as a preventive of such evils; but, unless it be very deep, the remedy will be but temporary; for as in dry weather the roots will always delve a great depth after water, they will in time reach the bottom of the vegetative soil; and as when there they cannot get back again, they must, at particular seasons, be subject to the same effects as in a shallow soil, resting on a wet subsoil; farther, the food collected by the roots at a great depth is always unwholesome, and more productive of wood and leaves than of seeds and fruit.

Q. When these defects naturally exist, how are they to be remedied?

A. The best and most effective means is to form an artificial substratum or foundation to the bed or borders, of stone, brick, slate, or cement, laying this bottom on such a declination as to permit superfluous water to drain off. It has been remarked by the most intelligent gardeners, that the most healthy and productive old fruit trees are found growing in about twelve or fifteen inches of vegetative soil, resting on a limestone basis; and the author himself has grown the finest peaches and pears in a soil of six inches resting on a pavement. We cannot, there-

fore, do better, when planting fruit trees, than imitate nature, both in this and in all other respects. The expense attending such a preparation may be great; but it must be considered that when once done, it is for ever done: it is not like the effect of many other operations, which require repairing and repeating at short intervals. Fruit in large quantity and of fine quality may certainly be produced without this preparation; but, excepting in such gardens as are naturally formed as above described, fruit trees, and particularly the finer sort, such as peaches and nectarines, &c. and apples, pears, &c. are well known often to fail after a few years; for, however healthy and productive they may have proved during the early stages of their growth, they afterwards gradually become diseased and sterile; this is occasioned by the roots delving too deep and being surrounded with unwholesome and stagnant water.

Q. In cases where the expense of such preparation cannot be afforded, what is the best mode of proceeding?

A. In many cases, cutting and forming drains, so as to draw off superfluous water, will be productive of great good. When the soil of a garden is retentive of moisture, and too close and adhesive to admit of a free extension of the roots of plants, it is a good practice, when planting trees, to form a stratum for the roots, in the following manner: throw the native soil out, to the depth of from nine to twelve inches, and of sufficient extent horizontally to admit the full spread of the roots; having smoothed the

bottom in a declining position, lay on it a stratum of about four inches of an open sandy soil; for this purpose the scrapings of roads that are made and repaired with hard stones will answer well; and even pulverised flint, or drift siliceous sand, will do; for although the siliceous loam, when exposing a surface to the action of the rain and the sun and the air, is apt to form a hard and impenetrable crust, if the proportion of the sand or gravel be sufficient to keep it open, it will, when buried, be attractive of moisture, and in this situation admit of the roots ranging freely through it; it will also facilitate the action of water, and prevent its stagnating about the roots; and if this stratum for the roots be covered down or over with from four to eight inches of the common soil of the garden, the trees will grow as well, and be equally as productive, as if the whole of the soil had been prepared to a greater depth.

Q. Are we then to conclude that the cause of disease and barrenness in old fruit trees, is water stagnating about their roots, or the roots being grown too deep in the earth?

A. There are other causes certainly, but there can be little doubt that this is the general cause; at any rate, stagnant water is quite sufficient to reduce trees to such a state, which has been demonstrated by repeated experiment, and will be more fully explained when treating of the diseases of trees and plants.

Q. What are the indications, in the appearance of *plants, of* their being injured by stagnant water?

A. When plants that are fairly exposed to the action of the sun and the air, assume a yellow colour in their leaves, it indicates stagnant water; and the production of carburetted hydrogen and an excess of inert carbonaceous matter are indicated by the same appearances; when they grow luxuriantly during summer, and the young branches canker and die during the winter and the following spring, it shows that the roots are grown so deep as to be immerged in an unwholesome soil, or, as is frequently the case in a soil that is surcharged with stagnant water in the winter, but which is dry in the summer.

Q. Then what are the remedies for such evils, when thus indicated by plants and trees?

A. When the cause is an excess of carburetted hydrogen, or inert carbonaceous matter, the most immediate remedy is a liberal supply of lime water or a covering of quick lime on the surface and water poured on it, or a solution of potash; but when the cause is stagnant water, occasioned by an impervious subsoil, and it cannot be removed by draining, the most certain remedy will be to take up the trees or plants and replant them in a soil and subsoil prepared as before explained. Trees of fifteen or twenty years' growth may be thus treated without the loss of a crop of fruit, or with the loss of perhaps one or two years' crops, particularly if on transplanting care be taken to injure the roots as little as possible, and when replanted to cover and surround the roots with an open sandy soil. But if the cause be a retentive

clay soil on the surface, the remedy must be to open it by an admixture of sand or ashes, &c.

Q. Do plants indicate by their growth and appearance any other defects in the soil, or any particular deficiency?

A. When plants advance but little in their growth, and assume a very dark or blue-green colour, it shows a want of water, or an obstruction to the action of the capillary attraction; and when a plant is of a light green colour, and is diminutive and puny in its growth, and there is evidently no want of water, it shows a want of carbonaceous matter or a general deficiency of nutriment. If plants and trees grow very luxuriantly in branches, forming large leaves and producing but little fruit, it shows that there is a luxuriant supply of hydro-carbonate, or an excess of carbonaceous matter, lying at a great depth from the surface, and a want of oxygen; when the leaves and branches are deformed and distorted by blisters and blotches and by irregular contractions and contortions of the stalks, fibres, veins, or ribs of the leaves, or when tumours break out on the leaves and shoots, it shows that an excess of putrescent carbonaceous matter containing nitrogen surrounds the roots. But the causes of such effects on plants and trees, and the means of preventing them, will be more particularly explained in the chapter on the food of plants.

Q. What are the indications of health, vigour, and prolificacy?

A. A profusion of leaves of a rich dark green colour, inclining to a purple brown, with strong thick shoots, and short spaces between the leaf-buds.

Q. A want of water may be supplied; but how is an obstruction to the capillary attraction to be remedied?

A. As such obstructions can take place only in tenacious or argillaceous soils, it may be removed by an admixture of calcareous matter or sand, or coal-ashes. By breaking and turning over the surface, and keeping it open and pervious to the air, other evils will also be much lessened; particularly, if these operations are performed as soon and as often as the surface is first made soft by water, and then becomes dry and baked.

Q. May not a deficiency of carbonaceous matter be made good by a supply of dung?

A. Yes; this is fully explained in the chapter on the food of plants.

Q. In case of an excess of carbonaceous matter, or its lying too deep in the earth, what is the best remedy?

A. If the soil be almost or entirely formed of hydro-carbonate, or decomposed vegetable matter, an admixture of calcareous sand, and a dressing of slaked lime and potash, will make it immediately fertile; but if the soil be an admixture of sand, and undecomposed vegetable matter, which is often the case with bog soils, burning a good part, and mixing it with the remainder, or giving it a dressing of slaked

lime and potashes, or the urine of animals, are the only means of producing fertility; the action of which substances are chemical and mechanical, as will be hereafter explained.

Q. When the soil is shallow, and cannot well be increased, what is the best means of sustaining plants and trees in dry weather, and of preventing the roots from delving into the subsoil?

A. Liberally supplying them with water; this may be done by pouring water evenly on the surface; or a better mode is by making holes, and pouring water into them, for when the surface soil is kept sufficiently saturated with water, the roots will seldom delve deep.

Q. But what is to be considered a liberal supply of water?

A. As much must be given at a time as will saturate the vegetative soil to its proper depth; that is, from nine to twelve inches; and this must be repeated as often as the soil is found to be dry an inch or two deep. When a less quantity of water is supplied, it often does more injury than good to plants; for when in want of water the roots penetrate deep, and, under such circumstances, a small quantity of water on the surface checks the capillary attraction; thus the roots that are grown deep, which are those on which the plant is made to depend in times of great drought, are deprived of their supply of water, and the plant exerts its efforts to throw out horizontal fibres; by the time these are formed, and the young

shoots extended, the supply of water on the surface, again fails, and they are again checked, and perhaps destroyed; thus the efforts of the plant being uselessly exhausted between the two extremes of a supply and a deficiency of water, it naturally declines in its growth; and hence arises the general opinion that watering in dry weather injures, more than it benefits, plants.

Q. In cases where the soil is a stiff clay loam, what are the best and most ready means of rendering it friable, or sufficiently open to maintain those plants which are generally cultivated?

A. Clay and stiff loams are readily brought to a friable and working state by a liberal supply of lime, or by an admixture of ashes; and the best method of applying them is to throw them evenly over the surface of the soil, an inch or two thick, immediately after it is roughly dug or turned up; and before it is raked over, and as soon as the soil will break easily or work well, to rake and mix it, so that the soil and the lime or ashes may be thoroughly incorporated three or four inches deep: when this is done, dig and turn over the soil again, and throw over it another coat or covering, and mix and incorporate the whole well together as before. By this mode of management the stiffest soil may be brought into good condition for sustaining any description of garden crop in a very short time; and a proper proportion of lime or ashes being thus at once blended with the soil, it will never want any other addition

than occasional supplies of carbonaceous or decomposed animal and vegetable matter. Calcareous substances pulverised or reduced, in sufficient quantity, will also produce the required change. Next to these, clay itself, burnt and well broken, will be found to reduce a stiff clay soil to an open and friable state.

Q. Digging, ploughing, and turning up the soil, and suffering it to lie fallow, are operations considered to be necessary to fertilise the earth; upon what principles are they so considered?

A. Upon both chemical and mechanical principles; as the earth contains a quantity of the detached roots of vegetables and other imperfectly decomposed matters, these are, by such operations, brought on the surface; on their being exposed to the sun and the air, the superfluous water is discharged from them, and by this exposure such substances are induced more readily to attract and combine with oxygen, and thus to form oxycarbonate, rather than carburetted hydrogen and hydrocarbonate—and the oxycarbonates are more fructifying than hydrocarbonates. Thus by the chemical action of natural principles, the soil is reduced to a state the best adapted for the production of flowers, seeds, and fruits; and as by breaking the tenacious part of the soil, and more intimately blending it with the calcareous, siliceous, and carbonaceous parts, it is more equally pulverised, and rendered more capable of sustaining a more perfect and equable capillary attraction, as well as of forming a better and more easily penetrable and genial lodging and labo-

ratory for the roots; the mechanical principles are thus made more efficient. It is by the operation of those principles that the fallowing of land renders it more productive. On the same principles, the growth of vegetables is also much assisted and forwarded by frequently breaking and stirring the surface of the soil only, particularly when this is done so as not to disturb the roots; indeed so great have been the effects of hoeing and loosening the surface, in the intervals between growing plants, that the very ingenious author of a treatise on the Operation of Horse-hoeing, (Jethro Tull,) has put forth and attempted to maintain the doctrine, "that nothing more than a repetition of these operations is necessary to maintain land in a constant state of prolificacy;" another emiment author (Mr. Curwen,) who was a man of extensive practice, has expressed his belief, "That the vapour arising from the loosened and pulverised surface of the soil is taken up and appropriated as food by the leaves of the plants." Hence he concludes that the luxuriant growth of a crop of cabbages, which followed such an operation, was caused by the liberal supply of nourishment raised by evaporation, and consumed by the leaves. However, every practical gardener must know that without occasional supplies of carbonaceous matter to the soil, all the stirring that can be given will not prevent the soil from being exhausted. If the leaves are capable of feeding on the vapours that arise, those plants that grow

alongside the soil that is stirred up must often reap the most benefit, as the wind must waft such vapour, and bring it more within their reach than of those which grow in the pulverised soil, whose leaves are placed immediately over it; but this is never found to be the case. There cannot be any doubt that by breaking up and turning over the soil, particularly that in which putrescent dung has been buried, carburetted hydrogen gas is liberated and discharged, and that the plant is thereby benefited; but in such cases the benefit arises from the plant being relieved from an excess of unwholesome food, and by the more perfect reduction of the carbonaceous matter to a soluble state, rather than from the supply of an additional quantity. By this operation, also, capillary attraction is promoted, and stagnant water dispersed, and consequently the soil made more capable of absorbing a due quantity of fresh water.

Q. Does not burning the soil increase its fertility; and if so, on what principle does the operation of fire thus act?

A. No doubt the partial operation of fire on soil increases its fertility, both by increasing its mechanical and chemical powers. By burning a portion of a clay soil, and pulverising and mixing it with the remainder, it is rendered less tenacious and retentive of water; in consequence it forms a better medium for the working of the roots; and hence it also admits of and sustains capillary attraction, and

thus furnishes more sustenance to plants. By reducing the vegetables and vegetable matter to ashes, potash is produced, and thus such inert carbonaceous matter as may be contained in the soil is more perfectly decomposed, and rendered immediately available to plants—and the soil is thus made prolific. But it must be observed, that as by these operations the carbonaceous matter contained in the soil is reduced to that state in which it is more quickly consumed by plants, it must be the sooner exhausted. Consequently, unless those soils that have been submitted to the operation of fire are afterwards replenished with carbonaceous matter, they must in a very short time become sterile.

PART III.

OF THE NATURE AND PRINCIPLES OF THE FOOD OF PLANTS.

Q. As plants appear in every way so destitute of the power and means of collecting or consuming what is usually understood by the term food, such as is necessary for the sustenance of animals; how can you, by the use of this word, convey a more accurate notion of the nature and properties of the substances provided to supply the nourishment required by plants, than by the term manure?

A. There is undoubtedly a very great difference in the nature and formation of animals and plants; yet, as will be shown, the dissimilarity is not so great, but that the term food, in its general sense, is as applicable and descriptive of the substance required to nourish and sustain plants, as of that required to nourish and sustain animals; and we have shown the inadequacy of the term manure to convey correct notions of the effect of those substances that come under this denomination; at any rate, no other term in our language conveys a more correct and precise notion of the nature and properties of those substances supplied as nourishment and

of the effects produced by them, than that of food; and in a work like this it would be preposterous to attempt the coinage of new words. We know, that besides a lodging and protection from the changes incident to climate, animals must be supplied with a due quantity of some animal or vegetable substance to support their existence, to enable them to grow from infancy to old age, and to sustain them in health and vigour; such substances must be taken into their stomachs, and digested and disseminated through their bodies, and that these are called food: it is also proved that, besides the lodging and support afforded by the earth and water to plants, they also require a supply of some other nutritive matter, such as can be derived only from dead vegetable and animal substances; and that such nourishment must be taken into their bodies, and diffused through their systems. As, then, there is not only an analogy in the nature and the principles of the nutrition required by plants and animals, but in its application and appropriation also, we cannot more clearly express ourselves than by the use of the term food.

Q. But that which forms the food of animals is solid in substance, and requires jaws to masticate, stomachs to digest, and bowels to abstract and pass off the excrementitious part of the food and drink. Plants do not possess those organs; then does not this disprove the resemblance?

A. No; the food of animals certainly consists of solid substances, and animals require drink besides;

but although plants cannot take anything into their bodies that is not in a liquid state and dissolved in water; yet as such liquids, when prepared, contain and supply all the nourishment required to sustain plants, its properties are more clearly comprehended in the term food than in that of drink, or any other familiar term. Plants, indeed, have not jaws for masticating nor stomachs for digesting their food, because these are not necessary; for plants being made to be stationary in the soil they are doomed to occupy, the offices of these organs are easily and duly performed by accompanying agents; thus the mastication is performed by animals, and the digestion by the earth. But although, as these offices are performed for plants by agents, plants can have no occasion for jaws or stomachs to reduce and digest their food; yet they must possess the power of decomposing the substance after it is thus reduced and taken in by the roots, of recombining its elements, as well as of appropriating that which is required for their various purposes, and expelling the remainder; and they accordingly are endowed with these powers.

Q. Can this be proved?

A. Yes; animal and vegetable matter being by nature made the food of animals, whenever and wherever such matter is accumulated or exists, animals assemble and devour it; and as it is proved by observation and experiment, that the excrement of animals forms a more nutritive food for plants than any other substance, animals may be considered as

as performing the office of mastication for plants. is also proved by experience that one kind of il is more productive of health, vigour, and olificacy than another; and as this, as has been own, is determined by the mechanical and chemical wers of the soil, those mechanical and chemical wers may be considered as performing the office the digestive powers for plants; for accord- g to the composition of the soil, and the cir- mstances under which it is placed, will the de- mposition and preparation of the food be effected. ien again, as it is proved by analysis that all the ferent parts and productions of a plant vary accord- g to the proportions of the elementary matter of iich it is compounded, it is obvious that plants ist possess the power of decomposing the food ken in by the roots, and of selecting, apportioning, d appropriating its elements, in due and necessary oportions; and as in the adjustment of those pro- rtions some of the elements may be in excess, it ust be necessary that a plant should possess the wer of passing off or disposing of such excess; and is proved that this power is possessed and the ice performed by the leaves. Thus, as four ele- entary substances only compose all the various parts id productions of plants, namely, oxygen, hydrogen, rbon, and earth; and oxygen is the only element iose existence in excess would create disorder, the ives have the power of expelling oxygen in the

form of gas, whilst they are exposed to the influence of the sun. All the hydrogen, carbon, and earth, that are not wanted for other purposes, are employed in the formation of the leaves; and as these are annually thrown off by the plant when they have performed their office, the substance of which they are formed, which is principally hydrogen, may be considered as excrementitious.

Q. But when animals have devoured the food within their reach, they have the power of shifting their quarters, whilst plants are stationary; how then can the resemblance be said to exist in this respect?

A. True; plants are stationary, and cannot shift their quarters to obtain a fresh supply of food, when that within a given space is consumed; but when all the food within that space is consumed by the roots, they have the power of extending themselves beyond it, and this in proportion to the bulk of stem, branches, and leaves; so that it will always be found that whatever extent of surface above the earth, the branches may expose to the air, the roots, when unobstructed, will extend and expose to the action of water a proportionate surface under the earth.

Q. Again, it has been observed, that when animals feed on unwholesome food, or consume too great a quantity, disease is the consequence. Do plants also resemble animals in this respect?

A. Yes, precisely: for whenever putrescent animal and vegetable matter, or stagnant water, is placed and

kept in contact with the roots of most plants, disease quickly follows, and often death.

Q. But is it not usually believed that all the diseases to which plants are subjected are derived from the air, or what is called blight; if so, how is this proved to be erroneous? or how does it appear that the diseases, or the death of plants and trees, are produced by anything peculiar in the quality or composition of the substances supplied as food?

A. Agreeably to the axiom,—establish the cause, and the effect will follow; remove the cause, and the effect will cease. It is found that when animal and vegetable matter in a putrefying state is placed in contact with the roots of plants and trees in large quantity, and kept for a long time saturated with water, disease will follow; when such disease is found to exist, if the obnoxious matter be removed, or if substances that will check and correct the effects of putrefaction and stagnant water be applied, a cure will be effected. If the same animal and vegetable matter be perfectly decomposed by being exposed a proper time to the influence of the sun and the atmosphere, or if it be prepared and dissolved in water by the addition of lime and alkaline salts, which prevent putrefaction, and then added to the soil in moderate quantities and in such a manner that its nutritive qualities may be equally distributed among the roots, it will sustain plants in health, vigour, and prolificacy. Thus, then it is proved that unwhole-

some food is the cause of disease; and that at the same time that animal and vegetable matter is rendered nutritive to plants by a proper decomposition, it is also divested of some pernicious element or principle.

Q. How is it proved that any pernicious principle exists in the substances which supply the food of plants?

A. As disease is produced, when animal and vegetable matter is supplied in one state, and not when supplied in another state, it may fairly be concluded that some elementary principle which exists in the one and not in the other, makes the difference and is the cause of the disease.

Q. Can it notbe ascertained what this pernicious principle is?

A. By ascertaining the elementary principles of which animal and vegetable masses are compounded, and which exist in the different states or stages of decomposition, as well as the elementary principles of the healthy and diseased productions of vegetables, and then comparing them, we may discover that element which is present in the diseased parts and absent in the healthy, and of course conclude that such element must be the cause of the disease.

Q. Are these conclusions sustained by experience?

A. By the decomposition and chemical analysis of the substances of both animals and vegetables,

we can ascertain the elementary principles of which they are compounded. Although we cannot demonstrate the truth of our analysis by synthesis, as we cannot create the living principle, we can collect and re-unite the elementary principles, and by repeated experiments, such as supplying vegetables with different substances containing the different elements as food, and accurately noticing the results, form a pretty correct judgment from analogy. Thus as animal matter, on analysis, is found to be compounded of hydrogen, oxygen, nitrogen, carbon, and earth; whilst all vegetable matter, except gum, is compounded of hydrogen, oxygen, carbon, and earth; and gum, which is the produce of disease, contains nitrogen; we may infer, not only that nitrogen is not required to sustain plants, but that when so combined with their food as to be consumed with it, it generates disease, and is therefore pernicious.

Q. But are the decompositions and compositions of animals and vegetables produced by nature, the same as those effected by art?

A. Whether the decomposition of animal and vegetable substances be left to nature, or controlled by art, as before observed, they are reducible to five distinct elementary substances, or primitive principles, viz. oxygen, hydrogen, nitrogen, carbon, and earth; whether their re-combination be left to the course of nature, or be produced by art, the effect on vegetation must be the same.

Q. How is it possible to conceive that all the

variety of vegetable and animal substances, as well as the air and water, can be compounded of five ingredients, simple substances, or primitive principles only ?

A. However different may be the effects produced on our senses by the immense variety of compound vegetable substances abounding in nature, the difference in their composition is proved, by chemical experiments, to consist only in the differing proportions of the ingredients or elementary substances which they hold in combination. To explain the various chemical processes by which all those things are proved, would be going farther into the art and science of chemistry than is required to forward our present object; but by way of elucidating what has been already stated, and of showing how readily one compound is changed into another in the course of nature, without any apparent addition or abstraction of any substance; and of establishing a correct notion of the general nature of those changes which take place; it may be well to describe the different proportions of the elementary principles that are found to form a few of the principal compound substances with which horticulture and agriculture are more immediately concerned, as well as the processes by which such combinations are effected. Thus, any given quantity of water is compounded of 85 parts oxygen and 15 parts hydrogen; atmospheric air is compounded of 22 parts oxygen, 77 nitrogen, and 1 carbonic acid; sugar, of 64 parts oxygen, 8 hydrogen, 28 carbon; starch, of 43·5 car-

on, 49·8 oxygen, 6·7 hydrogen; citric acid, of 33·8 rbon, 59·9 oxygen, 6·3 hydrogen; olive oil, of 79 rbon, 21 hydrogen; resin, of 75 carbon, 12·5 oxy-en, 12·5 hydrogen; gum, of 23 carbon, 11 hydro-en, 65 oxygen, 1 nitrogen; oak wood, of 52·5 carbon, 1·7 oxygen, 5·8 hydrogen.

Hence we may perceive, that as it is a difference nly in the proportions of these three or four ele-ientary substances which creates the difference in ie nature, structure, and quality of the various com-ound substances, if each simple substance be divided ito 1000 parts only, and combined with others in ll the various proportions such a division will admit f, such a variety of changes and combinations may be ffected as would produce a greater number of distinct esults than can well be calculated or than the mind an well conceive. The separation and combination f those elementary principles are generally effected y the agency of caloric or heat, which is chiefly nfluenced and brought into action by the sun, and y compression and electricity. As instances of this, re may notice the changes which are spontaneously roduced in sugar, by the natural process called ermentation; thus, if a given quantity of sugar be issolved in a given quantity of water, and exposed or a certain time to the air under a certain degree of eat, the liquid will soon become turbid and agitated, nd decomposition will spontaneously take place. This action or change is called fermentation; during he process it is found that a portion of the carbon

and the oxygen of the sugar are united and formed into carbonic acid; another part of the carbon, uniting with a portion of the hydrogen and the water, forms alcohol or spirit; whilst the compound thus formed is a vinous liquor, such as wine, beer, distillers' wash, &c. If the whole of this vinous liquor be then submitted to a higher degree of heat, another separation takes place by evaporation; for as the spirit is converted into vapour by a much less degree of heat than water, the spirit is thus raised in the state of vapour, and separated from the water; and such vapour being collected and condensed in a separate vessel produces alcohol, which is the basis of brandy, rum, gin, and all ardent spirits. On decomposing alcohol, it is found to contain 30 parts of carbon, 20·5 parts of hydrogen, and 49.5 parts of oxygen, in every 100 parts alcohol. If the same quantity of sugar be dissolved in the same quantity of water, and exposed for a given time to a greater degree of heat, and to the action of the sun and the air, the liquor, instead of parting with its oxygen, will attract and combine with an additional portion of oxygen, and thus form diluted acetic acid, or vinegar. The spontaneous process of decomposition and recomposition which forms alcohol, is called the vinous fermentation; that which forms vinegar is called the acetous fermentation. To show further the extraordinary power of caloric or heat, when put into action, in effecting new combinations and making great changes in previously existing compounds, we

may instance that to which sulphur, a natural production of the earth, is subjected; this of itself is a tasteless and insipid substance, but when exposed to the action of fire, or burned, it is converted into vapour, and during the process the burning sulphur abstracts and unites itself to so much of the oxygen of the atmosphere as to convert the vapour arising from it into sulphurous acid, or oil of vitriol.

Q. Do the natural processes of decomposition, which spontaneously take place, vary the same both in animal and vegetable matters?

A. When animals and vegetables are deprived of life, and left to the operations of nature, decompositions spontaneously take place in each; but the effects of such decompositions are determined by circumstances.

Q. What are the general processes of decomposition, and what are the general results?

A. The general process of the natural decomposition of vegetable and of animal bodies, as before observed, is called fermentation; and chemists enumerate four kinds or degrees of fermentation, which are distinguished as follows:—That which generally takes place the first is the saccharine fermentation; this is that decomposition and recomposition which converts the natural vegetable products of sap, juice, mucus, and farinaceous matter, into sugar. The second is the vinous fermentation, or that which converts a solution of sugar into alcohol or spirit. The third is the acetous fermentation, or that which converts the solution of sugar into vinegar. The fourth is the

putrefactive fermentation, and is that which effects the total decomposition or dissolution of a compound substance, and the complete disengagement and dispersion of all its parts.

Q. Do vegetable and animal substances undergo all those fermentations, before they can be reduced to a fit state for the food of vegetables?

A. No. The saccharine, vinous, and acetous fermentations are confined chiefly to vegetable substances, and take place only under peculiar circumstances; when these occur, they retard and prevent, rather than facilitate, the decomposition requisite to render vegetable and animal substances fit for the food of plants; for the saccharine, vinous, and acetous fermentations not only convert the carbon into insoluble compounds, but generate carbonic acid and other acids; and it is found that fermented liquors which contain acid in large quantity, such as beer, cider, vinegar, &c., not only will not nourish plants, but that, when placed in contact with the roots in any considerable quantity, they will obstruct and destroy vegetation. But if lime or alkaline salts sufficient to neutralise the acid in those liquors, and to absorb or expel the carbonic acid, be added to them, and the liquor be then placed in contact with the roots of plants, it will produce no injurious effect, but on the contrary it has been found rather to hasten the fructification of plants. The putrefactive fermentation, by effecting a total separation of all the parts forming the substance of a compound body, reduces the carbon to a state that

admits of its requisite re-union and combination with other substances, and it is thus prepared for the consumption of plants. But the affinity of one element for another is so great, and the transition so rapid, that unless the process be conducted under favourable circumstances, not only a great part of the carbon will be lost and dissipated during the decomposition, but it may, even after it is reduced to a proper state, be dissolved and carried away to waste; and it may also form combinations which will produce an unwholesome food.

Q. Can the intervention of casual circumstances so materially affect the results of the decomposition of animal and vegetable bodies as to render them either beneficial or injurious to plants?

A. Yes; during the natural decomposition of animal and vegetable substances, the different elements entering into their composition are not only disengaged and set at liberty, but in consequence of the natural affinity which one elementary substance has for another, a re-union and fresh combination of such elements instantly take place; we may therefore interpose and exert our influence so as to encourage, facilitate, and insure such combinations as are beneficial, and prevent such as are injurious and wasteful.

Q. It having been explained, then, that water contains in itself all the elements that can be required to form a plant, except carbon; that the earth furnishes all the aid that is necessary to sustain the powers of a plant and regulate the action of water;

and that carbon, or a carbonaceous substance, forms the pabulum or nutritive principle, or food; it may be concluded that carbon is all that can be required to be furnished, in addition to water and the earths, in order to form a prolific and fruitful soil. The grand question then is, how is this carbon best obtained, and how and in what state is it best administered?

A. This is clearly the object which requires our most particular attention; for although we find, as before observed, that carbon is a grand essential in the sustenance of vegetables, we find also that soils replete with carbonaceous matter, either from retaining an excess of water or from some injurious principle being combined with it, are not only often deficient in the power of sustaining vegetables, but are productive of disease; which is particularly the case when animal and vegetable matters are decomposed under water, or so deep under the earth as to exclude the influence of the air. Thus it is found that the carbonaceous matter of bogs, and the mud of some stagnant pools, will not sustain vegetables in health and vigour until they have undergone some chemical operation, and are thereby decomposed and some of their elements expelled, and some of them combined with some other and more active principle or element. Even when the vegetable and animal matter is reduced to such a state as to produce a gross and luxuriant growth of the trunk and branches, it is often found to oppose, more than favour, fructification.

Q. What is the principle or element that should be combined with carbon in order to render it fertilising, and how is such a combination to be effected?

A. These are questions that have puzzled almost all the chemists and physiologists who have written on the subject of the cultivation of plants, and have given rise to a greater diversity of opinions than any other object. It has been demonstrated that plants cannot grow without oxygen, and that oxygen and carbon have a great affinity for each other: hence a very general opinion has arisen, that from the large portion of oxygen contained in carbonic acid and carbonous oxide (these substances being compounded of carbon and oxygen only), they form the grand invigorating and fertilising principle. But this is opposed by the result of experience; for, as before observed, it is proved that fermented liquors, which contain a large portion of fixed air or carbonic acid gas, when brought in contact with the roots of plants, not only fail to nourish them, but absolutely injure and sometimes destroy them. Carbonic acid is found to exist in all the different substances which the earth contains, particularly in all calcareous substances, and a certain portion of carbonic acid gas is always floating in the atmospheric air; it is also proved that, in breathing, animals give out a large quantity of carbonic acid gas; but the carbonic acid produced in any of these cases is not observed to add much to

the fertility of the earth. Carbonic oxide may appear to be a much more likely compound of oxygen and carbon, to be applicable as the food of plants; but this is not found to exist spontaneously, and therefore has probably been overlooked by chemists; it is also of less specific gravity than the atmospheric air, and consequently, when formed in the open air, it must fly off through it. However, experience proves that in the common course of nature, carbon cannot be put in a fit state for the nutriment of plants until it has been combined with vegetable or animal matter in a living state; that is to say, that the carbonaceous principle cannot be added to the earth, so as to be made to operate in an efficient manner in nourishing plants and sustaining them in health and vigour, unless it has previously formed part of some living object; for we find, by practical experiment, that although carbon may be exhibited in a variety of forms unconnected with living bodies, it cannot, under any of these forms, be made to furnish nutriment to plants. Thus carbon is found to exist in the greatest quantity in the state of carbonaceous oxide or coal; but in this state it is insoluble, and consequently inapplicable as food for plants. It is likewise proved by experience that all calcareous substances contain a large portion of carbonic acid, particularly marble, limestone, &c.; yet these substances are found to add but little to the nutritive qualities of the soil, until the carbonic acid and water have been expelled from them by the operation of

fire, and they have been thus converted into lime. When in the state of lime, such substances have so great an affinity for carbonic acid, that it absorbs that which is brought in contact with it; yet notwithstanding this abstraction and absorption of carbonic acid by lime, it adds to the fertilising powers of animal and vegetable substances. Opinions have also been entertained, that carburetted hydrogen gas, or the stinking effluvia generated by putrefaction, forms an essential ingredient in the food of plants, and that such gas is absorbed and taken into the system by the leaves of plants; but this also is opposed by practical results; for, as before observed, putrefying substances producing carburetted hydrogen gas, when placed in contact with the roots of plants, generate disease, which is often followed by death; and when the leaves of plants are confined in putrid effluvia, they become mouldy and rot. That the leaves of plants do not possess the means of absorbing any substance and conveying it into the system, will be fully explained hereafter. But although it appears that a soil which produces carburetted hydrogen gas seldom or never sustains healthy plants, no doubt a soil that is replete with hydrocarbonate often produces plants of great bulk of stalk, leaves, and branches, which apparently are healthy and vigorous; but plants which grow luxuriantly to stalks and leaves are seldom fruitful. Lime also, when added to putrefying substances, prevents the formation of carburetted hydrogen gas, and, by

abstracting the carbon and promoting a union of the hydrogen with the nitrogen, forms ammoniacal gas, which, being lighter than the atmospheric air, passes off; thus lime, by expelling the nitrogen, makes the fertilising powers of carbonaceous matter more perfect.

Q. If the science of chemistry furnishes the means of analysing plants, and of proving that water and the earth produce all that is required to form a vegetable, except carbon; cannot chemists discover this fertilising principle, or the means of producing carbon in such a state that it may be furnished in the proportion required for certain purposes of cultivation?

A. Although it is clearly proved by chemical experiment, that a large portion of carbon enters into the composition of plants, and it consequently must be inferred that a supply of it is absolutely necessary to enable a plant to increase in bulk as well as to propagate and multiply its species; the means have not yet been discovered of obtaining or preparing carbon in a separate state, so that by its simple addition to the soil it may produce all the effects which result from the operation of manuring or adding decomposed animal and vegetable matter to the soil.

Q. How then can a knowledge of chemistry be beneficially exerted in the practice of horticulture?

A. It is not only proved by the physiological investigation of the structure of plants that they can-

not take any substance into their bodies by the roots unless in a state of solution in water; but it is also proved by experience, that, according to the nature of the solutions absorbed and supplied by the roots, will be the growth and productions of plants. Thus, whenever the roots of plants delve deep into the earth, they grow luxuriantly, but are not fructiferous, and in this case they are also often diseased; on the contrary, when the roots are found to grow in a horizontal position near the surface of the earth, plants and trees grow little to wood and branches, but are very fruitful. Now it is proved by chemistry, that, whenever animal and vegetable matter is buried deep in the earth or immersed in stagnant water, and there decomposed, the carbon unites to a large portion of hydrogen, and forms carburetted hydrogen gas and hydro-carbonate; and that whenever animal and vegetable matter is decomposed on the surface of the earth and exposed to the action of the sun and air, oxygen combines with the carbon in a greater proportion. As, also, it has been proved by chemistry, that the existence of oxygen and hydrogen, in greater or less proportion, in combination with carbon, constitutes the difference in the qualities of the different vegetable productions of gum, sugar, acid, oil, &c.; this leads us to conclude that it is the existence of these elements (oxygen and hydrogen) in greater or less proportion, in combination with the carbonaceous substances administered to and consumed by plants as food, which makes the great difference in their

growth, and in the production of flowers, seeds, and fruits: that is to say, that whenever hydrogen preponderates in the composition supplied as food to plants, it promotes the growth of wood, branches, and leaves; and that whenever oxygen preponderates, fructification is promoted and sustained. Chemistry also proves that whenever oxygen is combined in sufficient proportion with carbon, it forms carbonous oxide, which is insoluble in water, and consequently, in this state, is unavailable to plants. Chemistry farther proves that acids are the result of accumulated oxygen; and acids are proved by experience to be injurious to plants, when placed in contact with the roots. By chemistry it is likewise proved that when hydrogen exists in large proportion; in combination with carbon, it is not only insoluble and unavailable to plants; but experience proves that when in this state, and immersed in stagnant water, it generates disease. Whenever carburetted hydrogen gas is formed and set at liberty, the carbon is carried off to waste; and if confined about the roots, it produces disease. It must then be clearly necessary, before we can undertake the practice of horticulture with any certainty of success, that, besides obtaining a knowledge of the existence of those causes, we must learn how to establish and how to remove them, or how to counteract and prevent evil results, and to promote good ones; consequently, although chemistry does not point out the means of reducing or of preparing carbon, so that it may be applied at once in the exact propor-

tions that may be desired in a separate state, it points out those substances which are capable of yielding it in the greatest quantity; and by teaching us the nature of lime and alkaline salts, it also points out the best and most ready means of reducing carbonaceous substances to a proper state, so as to avoid the losses and injuries which inevitably take place when such substances are left to the course of nature to be decomposed. Chemistry likewise, by teaching us the nature and properties of lime and alkaline salts, teaches us how to apply them to the best advantage, as agents for counteracting the effects of excess, and thus regulating and increasing the fertilising powers of the soil.

Q. Have not lime and salts always been found to act beneficially when applied as manures?

A. Undoubtedly they have, in certain cases; but although the application of lime and alkaline salts have long been known to increase the fertilising powers of some descriptions of soil and compost, it is well known also that they sometimes produce a contrary effect; and consequently, as the nature and principles of their action have not been understood, they have not been so beneficially used as they might have been. It is proved by analysis, that neither lime nor potash contains carbon; these consequently cannot furnish the necessary element to a soil. Acting both as mechanical and chemical agents, lime and potash possess a double capacity for influencing the productions of a soil; for, by

counteracting the effects of excess, they convert the inert carbonaceous matter into an active and fertilising substance; and by breaking the tenacity of stiff argillaceous soils, they promote the action of water by percolation and capillary attraction. By their deliquescence, alkaline salts also attract and increase the supply of water to arid soils, and thus increase their fertility. But as cases may occur, where neither the mechanical nor the chemical agency of such substances can be beneficially exerted, where the qualities they are calculated to impart are already bordering on excess, it must be obvious that the application of lime and salts must sometimes be worse than useless.

Q. You speak of alkaline salts only: will not common or sea salt produce equally beneficial effects?

A. Common salt does not possess the caustic qualities of alkaline salts or lime, and therefore cannot promote the decomposition of carbonaceous matter; on the contrary, as it is antiputrescent, common salt obstructs the natural decomposition of animal and vegetable substances, and thus obstructs the production of food for plants. Neither does common salt contain carbon, nor any of the elements which are required for the formation of vegetables; and as it is never decomposed by exposure to the atmosphere, nor by immersion in water, it cannot promote nor produce any beneficial decomposition or recomposition. But as common salt destroys animalcula and vegetable life, when placed

in large quantity, in contact with living animalcula or vegetables; and as it is readily dissolved in water, it is, when placed in the earth, dissolved by the rains, and in the course of time carried away from the roots; and then, by the destruction of animal and vegetable life, and from their carbonaceous matter being left in the soil, salt may be said ultimately to enrich and increase the productive powers of such soil. As has been explained, putrefaction being opposed to fructification, whenever putrefaction exists, the application of common salt will check it; it might, therefore, when applied in sufficient quantity to produce this effect without injuriously affecting the roots, promote fructification, and thus act beneficially.

Q. How are alkaline salts and lime best applied to fertilise the soil?

A. Lime, when added to putrescent animal and vegetable matter, will make its decomposition more rapid and complete; but if lime, when used for this purpose, be mixed with animal and vegetable matter, before it is slaked or saturated with water, it will form an insoluble compound: consequently will, if used in this state, reduce and destroy, rather than increase, the fertilising powers of such matters. But if slaked lime, or that which has been saturated with water and thus reduced to powder, be added to putrescent or putrefying animal and vegetable substances, it will facilitate their decomposition, and render them more complete by reducing the solid substances to a soluble state; at the same time,

it will arrest and retain the carbon, and prevent the formation and dissipation of carbonic acid gas and carburetted hydrogen gas. It may also be necessary to observe, that as lime operates in the decomposition of animal and vegetable matter by absorbing its water and carbonic acid, and does not in its action make any addition to the proportion of oxygen, the carbonaceous result of such decomposition is much the same as hydro-carbonate, and consequently lime obstructs, rather than promotes, fructification and deteriorates the flavour of fruits. Alkaline salts not only hold a large portion of oxygen in their composition, and thus promote fructification, and mature the flavour of fruit; but they hold a metallic base also, which, being found in plants, is no doubt a necessary ingredient in their composition. Alkaline salts therefore, not only, by their caustic qualities, promote the decomposition and solution of carbonaceous substances, but furnish that proportion of those elements to the carbonaceous matter which is evidently necessary to enable a plant to fructify and mature its seeds and fruits, and also that which is required to furnish wood and branches; and being deliquiescent, alkaline salts also attract and increase the supply of water, which in dry seasons is very efficacious.

Q. Then as lime and alkaline salts act so differently, how can their combined application be beneficial?

A. Although they produce such differeut effects

separately, lime and alkaline salts often act more efficaciously in combination than when separate; thus lime will reduce many substances to a state of solution or decomposition, which alkaline salts alone will not; and alkaline salts reduce and decompose many substances which lime will not; therefore, when applied in conjunction, they reduce many substances to a more complete state of solution in water than either would do alone. And although lime does not contain oxygen, it does not exclude or prevent the supply of oxygen from being furnished by the alkaline salts, but, on the contrary, it promotes the attraction of oxygen in a mass of carbonaceous matter when exposed to the atmosphere; for, whenever vegetable and animal matters in a state of putrefaction are supplied with a due quantity of lime and potash, and exposed to the atmosphere, nitre is formed; and, as before observed, nitre holds a large proportion of oxygen in its composition.

Q. Under what circumstances can lime be beneficially applied?

A. When there is an excess of inert carbonaceous matter in the soil, or where putrefaction exists, lime can be used beneficially; as in those cases it renders such matter active and available, and corrects the evil; lime also breaks the tenacity of stiff loam or clay soils; and thus as the application of lime produces three essentials to fructification, that is, renders the carbon soluble, prevents putrefaction, and promotes the passage of water, it furnishes an exten-

sion of trunk, branches, and leaves, and prevents disease; and as large and healthy plants are better adapted to produce a large crop of seed and fruit than small and puny plants, lime furnishes the essentials for such production.

Q. But if nitrogen produces disease, how is this avoided when applied to plants?

A. Nitre, being antiputrescent, checks the decomposition of carbonaceous matter, and thus checks and prevents the over luxuriant growth of plants and trees; and as, at the same time, when dissolved in water, it probably parts with its oxygen, it thus promotes fructification and improves the flavour of fruit. But unless care be taken not to supply it in excess, and not to give it at an improper season, nitre will produce disease; particularly that disease which discovers itself in the peach tree, by blotched, blistered and distorted leaves and young shoots.

Q. Is animal and vegetable matter found to possess the fertilising powers in an equal degree?

A. This does not appear to have been an object of sufficient importance to be determined. Yet certain it is, that compounds of animal and vegetable matter are more immediately effective than either the one or the other in a separate state. But, as before observed, animal matter contains nitrogen; which is an elementary substance, not only not necessary to plants, (as it does not enter into the composition of any of the healthy parts or productions of plants,) but when blended and taken up with their

food, it causes disease; vegetable matter, therefore, as it does not contain nitrogen, must be much more productive of health and vigour; unless, indeed, the animal matter has undergone such a decomposition as deprives it of its nitrogen.

Q. Is nitrogen abstracted or expelled from animal substances during the process of decomposition, and thus separated from the soil, or rendered innoxious?

A. As the elementary principles of animal and vegetable substances are disunited and set free by the process of decomposition, they unite again in different proportions, and form other and different combinations; thus, nitrogen and hydrogen combine and form ammonia, which, being in a state of gas much lighter than the atmospheric air, passes off through it.

Q. It has been stated that the air is essential to the existence of plants, and that without it they will not vegetate; as nitrogen is a component part of air, if plants imbibe air, what becomes of it?

A. As plants are not found to expel or throw off, as excrementitious, any other of its elementary substances than oxygen and carbonic acid gas, and nitrogen is not found in any of the healthy productions of plants, we may consider this as a proof that plants do not imbibe air, and that a free access of air is only necessary, as it promotes and supports the process of decomposition and recomposition and other operations of nature.

Q. As it appears, then, that neither nitre, nor lime, nor alkaline salts, can supply carbon to the soil, are we to conclude that the fertilising powers of those substances consist in reducing such carbonaceous matters as the soil may contain or be supplied with, to a proper state for the consumption of plants, and in separating from the various compounds their pernicious and opposing principles?

A. Lime, and salts, can only increase the fertility of soils by dissolving the combination of certain elementary substances and principles, and facilitating the combination of others; and thus, by modifying the composition and dividing the wholesome from the unwholesome ingredients, they purify and reduce the food to that state which is required to sustain plants in health and vigour, and render them fruitful. But it must be observed, that every process always fluctuates between two extremes; and that to obtain the desired medium, it is as necessary to avoid the one as the other. Like the effect of medicines on animals, although a certain quantity will remove disease and establish health, a larger quantity will increase disease, and even produce death. Thus, a certain quantity of lime and alkaline salts added to putrescent animal and vegetable matter, or a certain quantity of lime, nitre, or potash, added to particular soils in which plants are growing, will produce the most beneficial effects; yet an over-dose or undue proportion will obstruct and destroy vegetation altogether. It is from the

want of a due understanding of, or an attention to, those principles, that we find practitioners contradicting each other; some extol the use of lime and salts as productive of great benefits, whilst others describe it as being worse than unproductive. When there is inert or undecomposed vegetable or carbonaceous matter for them to work upon, or when carburetted hydrogen is formed or exists in excess, lime and salts are found to be productive of fertility by rendering the inert matter available. Hence, also, as in proportion as the carbonaceous matter is rendered soluble, it is consumed by plants, the soil must be exhausted and become less and less productive until it is altogether sterile; therefore cases may occur where the application of lime and salts may be justly said to have produced sterility.

Q. As it appears then that the soils which were sterile, from the vegetable or carbonaceous matter they contained being imperfectly decomposed, or from its holding some opposing principle in combination, are rendered prolific by their being properly reduced and purified by the lime and salts, and that the carbon thus prepared is consumed by vegetables; are we to understand that the land becomes sterile in consequence of the carbon being exhausted?

A. Yes; and as it is usual to call lime and salts, when thus applied, as well as carbonaceous matter, manure, this shows how inadequate the term manure is to the explanation of the nature of the fertilising powers of the earth, and to the explanation of the

means of increasing or restoring those fructifying powers when exhausted.

Q. Has the knowledge of those principles led to the discovery of any particular kind of animal or vegetable matter, which has been found to produce a greater quantity of available carbon or a more immediately effective food for plants than another?

A. Yes; an immediately effective food was some years since discovered by the author of this work, in the serous part of the blood of animals, which being diluted with from four to six times its quantity of water, and applied by pouring it on the surface of the soil above the roots of a plant intended to be supplied with nutriment in sufficient quantity to saturate the soil at the full depth occupied by the roots, was found to produce the most fertilising effects.

Q. And is not every part of the blood equally as productive as the serous part?

A. Not immediately so; and for obvious reasons. In the first place, the clotted part is not soluble until it has undergone decomposition; when left to nature, this can only be produced by the putrefactive fermentation; and if, whilst in this state, it is brought in contact with the roots of plants, it will produce disease and death. Further, if the clotted blood be placed on the surface of the earth and decomposed there, a great part of its carbon will be dissipated and lost in a most disgusting gas or effluvia, such as carburetted hydrogen gas, &c.

Q. What then can occasion such different effects to be produced by different parts of the same substance?

A. A very great difference in the component elements of those two distinct parts of the blood; which is proved from the following results of a chemical analysis:—the blood of an ox, being permitted to remain undisturbed in a vessel for a day or two, separates or divides of itself into two distinct substances, which are called the serum and the crassamentum. The serum or watery part, being then poured off from the crassamentum or the clotted part, and each submitted to chemical decomposition, yielded as follows: 10,000 parts of the serum gave 8784 parts water, 980 albumen, and 236 alkaline salts; 10,000 parts of the crassamentum gave 5620 parts water, 1400 albumen, 2400 fibrine, and 580 colouring matter. The grand difference then is, that the serum contains no fibrine, and the crassamentum contains no alkaline salts; but that which occasions the greatest difference in their immediate effects on vegetation, as regards the supply of nutriment to plants, is that the carbon is held in a state of solution in the serum; which in this state is consequently immediately applicable as food for plants, whilst in the clot the carbon is fixed and insoluble, and therefore inapplicable until it is reduced by decomposition. And as it appears that the albumen in the serum is held in solution by a certain portion of alkaline salts, it may be concluded that the proportion of the serum and the crassamentum

in the blood depends upon the proportion of the alkaline salts contained in it; that, therefore, if sufficient water and alkaline salts be added to the crassamentum, the albumen which that contains will be dissolved, and reduced to a state of serum, and that thus the serum may be increased and the crassamentum lessened; which is readily proved to be the case. For if to one gallon of the clotted part of blood which remains after the serum has been separated and poured off, be added five gallons of water and four ounces of potash, (which is the proportion it bears in the serum,) and the mixture be stirred occasionally for eight or ten days, the albumen will be dissolved, and the liquid part will then be in a state equally as well adapted to the use of plants as the natural serum; and as the alkaline salts alone will not dissolve the fibrine in the crassamentum, if one-fourth part of a gallon of slaked lime in powder be added with the potash and water, the fibrine will also be dissolved in due time, and the liquid part will then be of the nature of hydro-oxycarbonate, and, as such, form an immediately nutritive food. Hence then it appears that lime and salts are very different in their nature and properties, although, in many respects, the result of their action, when placed in contact with animal and vegetable substances, is the same; for by the addition of lime with the alkaline salts to the crassamentum of blood, the fibrine is dissolved, which is an operation that the alkaline salts alone could not accomplish; as has been observed, the addition

of lime and alkaline salts to animal and vegetable matters also obstructs the different fermentations, and thus prevents the combinations and changes which would otherwise be effected by such processes. By the addition of lime, also, the production of carburetted hydrogen gas, or that which occasions loathsome smells and carbonic acid gas, is prevented; by the addition of potash, the combination of nitrogen and oxygen is effected, and nitre produced; or nitrogen and hydrogen are combined and passed off as ammonia; the nitrogen is thus rendered innoxious, by being held in combination with other elements, or by being separated and expelled.

Q. Are the constituent principles of blood different from those of any other parts of animal and vegetable matter?

A. Blood contains a larger portion of albumen; and albumen, in a state of solution, is more immediately fertilising to the soil than any other substance. The bones of animals contain a large portion of fibrine and albumen, and hence produce fertility, when ground to pieces and added to the soil. It is also well known that the soil is very much enriched by the result of the decomposition of mushrooms, as is shown by the rings which mark their growth in old pasture grounds, these being always covered with a more luxuriant vegetation than any other part, which is occasioned by the large quantity of albumen contained in mushrooms. It is well known also that the urine of some animals contains albumen, and that which con-

tains it is always the most fertilising; such is the case with the urine of rabbits.

Q. And can the fertilising effects of albumen be traced to any of the peculiar principles or elements of which it is compounded?

A. On comparison, albumen contains a larger portion of soluble carbon than any other substance except fibrine; and, for the reasons before explained, it is more immediately rendered available to plants than fibrine. By chemical analysis, 100 parts of albumen are found to contain 53 parts of carbon, 24 of oxygen, 7½ of hydrogen, and 15½ of nitrogen; and fibrine contains in every 100 parts 53½ parts carbon, 19½ oxygen, 7 hydrogen, and 20 nitrogen.

Q. As the serum of blood contains alkaline salts, and the serum is the most immediately nutritive substance known, is it not to be concluded that alkaline salts form a necessary ingredient in the food of plants?

A. No doubt, on the principles before explained, alkaline salts must give to the serum its active powers; but whether alkaline salts form a constituent part of the food of plants, or whether they act merely as chemical agents in dissolving and reducing the albumen to a fit state to unite with water, and thus form the food, is of very little importance to a practitioner, as in either case they are equally necessary. It has indeed been proved by experiment, that alkaline salts, when applied to a soil destitute of carbonaceous matter, will not supply the required nutriment to

plants; however, it is certain that potash is the sole production of vegetables, and that the leaves and stalks of almost all vegetables are capable of producing it, in a greater or less quantity, when reduced to ashes by fire and subjected to lixiviation. It must therefore be concluded that, whether plants consume alkaline salts or not, they must, by some means, be supplied with, and take into their system, the elements or basis of alkaline salts; and by a method of decomposing alkaline salts, discovered by Sir Humphrey Davy, those elements are proved to be oxygen and a peculiar metallic substance; but as no instance is known of such metallic substance existing in a separate state in nature, (nor indeed, from its great affinity for water, can it be kept in a separate state by art, except by such means as prevent its coming in contact with water or the moisture of the atmosphere,) we can suggest no means by which plants can be supplied with this metallic basis, unless it is supplied by the earth, which is held in solution by water, and thus imbibed by the plants as part of their food. As it has been explained that plants possess the power of decomposing the substance taken in as food, and that earths are metallic oxides, this suggestion seems well grounded.

Q. At any rate, then, it appears that alkaline salts, under certain circumstances, add much to the fertility of the soil; therefore a knowledge of the means of producing and applying them must be desirable?

A. As before explained, alkaline salts are obtained in the greatest quantity by art; that is, by reducing vegetables to ashes by fire, and submitting the ashes to lixiviation, and the liquor to evaporation; but the most productive natural process of producing them is by the urine of animals. Hence we may understand how it is that fire fertilises soils; and that the urine and excrement of animals, when decomposed together, afford more nutritive matter, than when either is decomposed and applied to the land separately.

Q. Does the urine of all animals alike contain alkaline salts?

A. Not in the same proportion: for instance, the urine of the horse analysed is found to contain as follows: every 1000 parts by weight contain 11 parts of carbonate of lime; 42 parts of alkaline salts; 7 parts urea; and 940 parts of water. The urine of the cow contains, in every 1000 parts, by weight, 3 parts phosphate of lime; 24 parts alkaline salts; 4 parts urea; and 967 parts water. Thus it appears that the proportion of alkaline salts and lime, in the urine of the horse, is nearly two to one to that in the urine of the cow; it is also well known that the urine and dung of the horse, combined with vegetable matters, such as straw, &c., which is produced in the stable, forms a much more effective compost than that of the cow, and the difference arises wholly from the difference in the proportion of the substances composing the urine; for the dung of the cow, by itself, affords a

more immediately nutritive matter than the dung of the horse by itself.

Q. As alkaline salts increase the fertilising powers of those substances with which they are naturally combined, may not other substances, which do not contain them, be made more efficient by the addition of them?

A. Undoubtedly: as, in the case of their being added to the clotted part of blood, they dissolve the albumen; so they may be used with good effect on all vegetable and animal matters that do not contain them in sufficient quantity.

Q. You say that alkaline salts are produced by burning vegetable substances, and lixiviating the ashes. Will all vegetable substances thus treated produce alkaline salts? are not the salts produced by the burning alone; and the lixiviation and evaporation merely resorted to, to separate the salts from the earth, &c., of the ashes? if so, will not the ashes of vegetables, mixed with the compost, produce the same effect as the pure alkali?

A. All vegetable substances, when burnt, will produce alkaline salts, but not in the same proportion; and the ashes mixed with the compost will certainly produce the same effect as the addition of the purified alkali, provided the proportion of ashes be sufficient to produce the proportion of alkali required, for the lixiviation merely separates the salts from the ashes.

Q. Although it is found that by burning vegetable

substances, and by their consumption as food by animals, alkaline salts are produced, and it has been proved that by the application of alkaline salts, by the operation of fire upon the earth, and by the application of the urine of animals, increased fertility is produced; we know that vegetables grow in great luxuriance where fire has not been applied, and where animals do not feed in sufficient numbers to produce any great effect by their urine. How then are these vegetables supplied with alkaline salts?

A. Such may appear to be the case—there may be no immediate traces of fire, and there may not appear to be any of the larger sized animals to feed on the vegetables; but wherever there is an accumulation of vegetables or vegetable matter, there is always a sufficient number of small animals to feed on them; no doubt these furnish the means of conversion, particularly when such vegetable matter is not immersed in stagnant water.

Q. But will not vegetables, nor vegetable matters, produce alkaline salts when immersed and decomposed in stagnant water?

A. No: neither pure vegetable substances, nor any compound of vegetable matter, when immersed and decomposed in stagnant water, will produce alkaline salts; these cannot be produced but by the aid of fire, or by the process of digestion in the stomachs of animals. It may, therefore, be concluded that in the formation of alkaline salts, the metallic basis is obtained by the plant from the earths contained in

its food; and that the oxygen, which is required to be combined with it to form the compound, is furnished and united to it during combustion, or by digestion in the bowels of animals. Consequently, as alkaline salts cannot be produced without the action of fire or that of the animal powers, the aid of those powers is necessary to maintain the fertility of the earth in the production of vegetables.

Q. Such, then, being the elements and principles of fertility, and the nature of the food of plants; are we to conclude that the digging in or burying of vegetable substances before they are decomposed, will produce a different effect to that which is produced when they are properly decomposed before they are buried?

A. Certainly: the matter resulting from the decomposition of vegetables buried under the earth or immersed in water, must contain an excess of hydrogen, and consequently be rendered inert; and if when combined also with sufficient oxygen to render it active, it be applied to plants as food, it produces a luxuriant growth of trunk, branches, and leaves, but retards and prevents fructification. Further, if undecomposed vegetable substances are placed in any great quantity about the roots of plants, putrefaction will take place; and as such matter is retentive of water, it will produce carburetted hydrogen gas, which is productive of disease.

Q. How then are those substances which form the food of plants best collected and prepared?

A. This must be determined by the object for

which plants are cultivated. The best means of providing and preparing a compost for the purpose of producing seeds and fruits, is to appropriate all the edible parts of the refuse of the garden and the kitchen to the feeding of some animals, to collect their dung and their urine together, and let it ferment in a mass; to prevent obnoxious smells, and the loss of carbon, you should occasionally throw over it a covering of fresh-slaked lime in powder; taking care to place the accumulated mass in such a manner that no part of the liquid which may drain from it run away and be wasted. It may be remarked, as a consequence of ignorance, that although the urine of the horse and other animals is proved to be so valuable and fertilising, in most cases, all that is not absorbed by the litter in a stable is suffered to drain off and is wasted; whereas, if the drains of stables and stable-yards were made to terminate in a cistern, and the urine collected, it might and would, if thrown on the compost heap, much increase its value; and if thrown over the surface of soils replete with carbonaceous matter, which most black soils are, it would facilitate and sustain the fructification of plants and trees growing in such. The gross or woody part of the refuse, which is not edible, should be collected, dried and burnt, and the ashes carefully collected and thrown on the putrifying mass of dung. As this mass becomes decomposed, it should be taken and spread over the surface of those parts of the soil which require replenishing,

and, if possible, it should be so arranged as not to be dug into or buried under the soil, until it has been on the surface for twelve months, or as near that time as may be convenient. The liquid that runs from the putrifying mass of dung, &c. during its decomposition, may be thrown back upon the heap occasionally as it accumulates, and of course a drain and pit should be formed to collect it for this purpose; or if wanted, this liquid may be applied in the manner that has been recommended for the serum of blood, and diluted in the same manner with water; indeed, where it is more desirable to supply the nutriment in a liquid state than solid, the decomposed dung may be immersed in water, and after it has remained a sufficient time for its dissolution, the liquor may be drained off, and in this state applied. If the dung has not been supplied with alkaline salts by the addition of a sufficient quantity of vegetable ashes or urine, alkaline salts may be added to the water during the immersion; this will not only hasten the dissolution of the matter, but, for the reasons before explained, render it more immediately and effectually nutritive and fertilising. The proportion of alkaline salts to be added may be about one ounce of potash; if lime be required, one quart of the powder of slaked lime to about four gallons of water, and about one cubic foot of the decomposed carbonaceous matter, or rotten dung. In cases where the quantity of urine produced is such as to render a pit necessary to retain it, the dung

and urine may be collected in a pit; but whilst in this state, no other water than what may be supplied by rain on the surface should be added to it. When the mass of fermenting matter thus collected is found to give out a disgusting smell, it should be supplied with a sufficient quantity of fresh-slaked lime to prevent it. However disgusting the effluvia arising from dung and urine of any kind may be, they may be effectually rendered inodorous by the addition of slaked lime; and as too great a quantity of such fertilising compost cannot well be provided, every description of excrement may be collected and thrown on the heap or into the pit; for of whatever nature or however disgusting it may be, it will, when decomposed, be all reduced to the same elementary principles.

Q. Is the spreading of the dung or compost over the surface of the soil, and permitting it to remain there for so long a time, so effectual a mode of fertilising the soil and nourishing the plants as the digging in and incorporating it with the earth?

A. This, as in the former process, must depend upon the object we have in view when preparing the soil: whether the object be to produce the greatest quantity or bulk of stalk, branches, and leaves, or the greatest quantity and finest quality of flowers, seeds, and fruits; for although both these objects depend upon the supply of a due quantity and quality of food, it is difficult to obtain both at the same time and by the same supply of compost. For although when a luxuriant supply of putrifying carbonaceous

matter has been furnished by burying, the soil is found to produce plants of a large and luxuriant growth, such plants, if the leaves, stalks, or roots be the edible parts, will be found to be watery, rank, and unwholesome. If the flowers, seeds, or fruits be the object of cultivation, although this part of the produce of such plants and trees may be brought to a larger size by such an application of carbonaceous matter, it will often be diseased and inferior in flavour or quality, and generally deficient and always uncertain in quantity: for a gross and luxuriant habit in a plant or tree is always opposed to fructification. These conclusions will be found to be supported by the productions of all kinds of fruit trees and plants, as well as of esculent vegetables, particularly all the cabbage tribe, brocoli, sea kail, &c., as also peas, beans, turnips, potatoes, &c.; for all these vegetables, when grown in putrescent dung, will grow more to leaves and stalks than to seeds and roots and tubers, and the edible parts will possess a rank, bitter, and nauseous flavour; whilst those of the same kind, produced from the same seed, but grown in a soil supplied with a properly prepared compost or with a compost thrown on the surface, will be sweet, pleasant, and nutritive. The flowers, seeds, and fruits of plants thus supplied, will also be more perfect in quality and flavour, and much greater in quantity; and the effect of the compost, when thrown on the surface, will be as lasting and permanent as when buried in the soil.

Q. How is it known that an excess in the quantity of food, and a difference in the quality, are the causes of such effects?

A. It has been demonstrated by repeated experiments, that large fruits and vegetable productions are generally inferior in flavour to small ones. But the laws of nature, which regulate and determine the relation of those effects to their causes, will be more easily understood when the nature and office of the leaves of plants are explained. In the performance of all his operations, a gardener will do well to observe the course of nature, and to consider it to be his duty to assist nature, instead of indulging in the presumptuous attempt to make her more perfect by forcing her out of her regular course. In the course of nature we find that those substances which give to the earth the most fertilising and fructifying principles, are spread over its surface and there left to undergo the necessary decomposition or preparation; and as they are thus progressively decomposed and reduced to a soluble state by oxidisement or otherwise, the carbonaceous matter is dissolved and taken up and combined, and conveyed to the roots by water. We cannot then do better than adopt this course; at any rate, plants placed under such circumstances as to receive their nourishment in this manner, will always be found to be the most healthy and the most prolific in those productions which supply the wants and administer to the pleasures of mankind; whilst the soils thus

treated are always more immediately, as well as ultimately, fertile.

Q. But when animal and vegetable substances are exposed to the sun and the air, will they not be reduced in quantity, and great part of their nutritive principles be carried off by evaporation, dissipated and lost?

A. When animal or vegetable matter is exposed to the sun and the air, it will of course be reduced in weight and bulk by the loss of water by evaporation; but the quantity of the nutritive principle will be rather increased than diminished by the attraction and combination of oxygen; for by this combination the carbonaceous matter will be made soluble, and the separation or combination of nitrogen will be promoted; and that part which is carried off can only be carburetted hydrogen gas, which would have been more injurious than beneficial, if retained. Hence it is found by florists, that, when animal and vegetable substances, which are intended to be mixed with the soil, are first thoroughly blended together, broken, decomposed by fermentation, and then exposed to the influence of the sun and the air, by being turned over at short intervals for at least twelve months previously to their being supplied to plants, they form a compost that will impart the greatest fertility to the soil and produce and sustain plants of the most perfect health, vigour, and prolificacy. Carbon can only be dissipated and lost by excessive fermentation; which is the less likely to take

place when the substances are thinly spread over the surface of the earth, than when accumulated in masses or buried in the earth: for when left on the surface, as the carbonaceous matter is reduced to a state to dissolve in or be combined with water, it is carried to the roots of plants by the water supplied by rain or otherwise.

Q. How is it known, when plants are barren, that they are made so by an excess of carbonaceous matter, or by unwholesome food? and when they are in this state, how is it to be remedied?

A. When plants and trees are barren from an excess of hydrocarbonate, their leaves and shoots are very large, and they produce no blossom-buds; when a tree is in this state, unless means are adopted to alter the nature of the food or lessen the supply, it will require many years' growth before it will fructify. There are many means of lessening the supply of food, which are elsewhere explained; but the most effectual mode of altering the nature of the food, and thus forwarding fructification, is by supplying the soil occupied by the roots with lime-water and potash, or a solution of nitre. When the carbonaceous matter is inert and inapplicable as food, the addition of alkaline salts will remedy the defect; and when hydrocarbonate is in excess, the leaves and shoots of plants and trees are large and spreading, they are of a yellow colour, weak and attenuated, and the blossoms fall off prematurely, before impregnation, or the fruit falls off at the kerning or stoning,

or if it passes this stage of growth, it fails to attain maturity: in this case, the trees should be supplied with a solution of nitre, a little while before the blossoms begin to open, in the proportion of two ounces of nitre to six gallons of water; which may be done by making holes with a potatoe fork all over the surface of the soil occupied by the roots (which always extend over as large a surface as the branches will cover) and pouring in the solution. When trees have been thus treated, the flowers, seeds, and fruits have been brought to attain the utmost perfection and maturity, both in colour and flavour; and one such dressing, or supply, has proved sufficient for two or three years. But after having been thus treated, and having borne full crops of fruit for two or three years successively, the trees have been so much exhausted as scarcely to produce any young wood; they were then supplied with a solution of blood with potash, prepared as before described, and the following season they grew most luxuriantly to wood and leaves. The result of this experiment demonstrates the truth of the conclusions which we have before explained, as to the nature and principles of nitre and alkaline salts, when applied to the soil to promote fructification.

Q. Do all plants feed on the same substances, and require the same preparation of food?

A. There can be no doubt that carbon forms the pabulum, or grand sustaining principle, of all plants; the serum of blood also has been found to agree with

every description of plant under cultivation; and nitre, acting as an anti-putrescent and furnishing supplies of oxygen, has been found to produce the same effects on a great variety of plants and fruit trees, particularly on peaches, nectarines, apples, pears, and cherries. Still it is certain that the same preparation or compound of carbonaceous and other substances will not produce all the effects that may be desired in the growth of all plants; for, as has been observed, a rank and luxuriant growth in a plant or tree is opposed to fructification; therefore, if such a rank and luxuriant growth be desired, that species of food which is composed of hydrocarbonate is best adapted; and it follows that the same food will not suit all plants. As, from the usual course of nature, it is impossible that carbon can be equally distributed, *i. e.* exist in the same state and in the same proportions, or occupy the same situations, on all parts of the globe; the all-wise Creator has, in his bountiful providence, formed plants for every situation, and endowed them with powers and propensities suited to feed on all the different compounds of carbonaceous matter formed in such situations, which can be requisite to enable them to maintain their growth in health and vigour. Hence we find that there are plants formed to live entirely in the water, plants formed to live entirely without water, and plants formed to exist and flourish in every intermediate degree of moisture. There are also plants that require but little carbonaceous matter;

others so voracious that they cannot well be supplied with too much: there are plants endowed with powers to enable their roots to perforate the stiffest clay, and to thrive best on the food that is collected from a great depth; whilst there are other plants whose roots can only extend themselves in loose, sandy, or gravelly soils, and exist and thrive on food supplied on the surface. In short, plants are formed with all the powers and propensities suitable to every soil and situation. The state of health and vigour of plants is also much influenced by the climate, and by their exposure to the influence of the sun and the air. Plants are therefore formed with different degrees of power to endure an exposure to the rays of the sun: some require to be constantly exposed, in order to be healthy and vigorous; whilst others cannot endure such an exposure, but thrive best when protected from it. Plants are also adapted to every degree of heat and cold to which they can be exposed in the open air. It must also be observed that the habits of some varieties of the same plants differ from each other; and that this is, in a great measure, determined by the condition of the soil and the climate in which the seeds are generated: thus, plants that are raised from the seeds of plants growing in a rich and luxuriant soil will require such a soil to maintain them in full luxuriance. This is clearly exemplified in the growth of gooseberries and currants; as great size and weight have always been the desired objects in cultivating these fruits, new

varieties have been successively produced, for many generations, from plants exuberantly supplied with hydrocarbonate; consequently the various kinds now grown require a luxuriant supply to maintain them of their full size and weight. Plants that are raised from the seeds of plants growing in a poor and meagre soil will be gross, diseased, and unfruitful when planted in a rich and luxuriant soil. The same evils will result from a change of climate. Plants that thrive well in a hot climate, will not grow well in a colder one, nor will those of a cold climate thrive in a warmer one; but many plants, after their seeds have been generated and grown in the same soil and climate for three or four successive generations, will become naturalised to such soil and climate, by degrees, more and more every year; and, after a time, will grow and flourish in them. It must therefore be an object of the first importance in the formation and management of a garden or plantation of fruit or forest trees, that the managers should be well informed of the peculiar nature and habits of every variety of plants they are about to cultivate; particularly as to the degree of moisture their habits are suited to, the texture of the soil, the quantity and quality of the carbonaceous matter required for their sustenance, the climate best adapted, as it is wet or dry, hot or cold, and the requisite time of exposure to the sun.

Q. Although particular plants require peculiar soils, is there no preparation or compound forming

a medium between the extremes, in which plants in general will thrive?

A. Yes. If to native loam, or to a soil that is composed of about two parts of sand, one of carbonate of lime, and one of argillaceous earth or vegetable mould, be added one part of perfectly decomposed animal and vegetable matter, duly saturated with alkaline salts, it will form a soil that, with a supply of water only, will sustain in sufficient luxuriance almost all the plants that are cultivated for their seeds, fruits, and roots; and although it may be difficult, if not impossible, to describe the exact proportions of the elementary principles or ingredients contained in every soil in which plants are found to thrive, yet the more minute the analysis, the more evident will be the fact, that the absence or presence of the elementary principles here described, and their proportions, determine its prolificacy. By exerting our influence over these, and attending to the laws of nature, we may determine or approach very near the point of perfection, at any rate sufficiently near for all practical purposes.

PART IV.

OF THE GENERATION OF PLANTS, AND THE PRODUCTION OF VARIETIES.

Q. ACCORDING to the proposed arrangement, we have next to consider how plants are generated and varieties produced and established, as also the use and office of the different parts of plants. Are all the parts of a plant formed for different purposes, and necessary to sustain it in health and vigour?

A. Yes: and from their not knowing this, the common practice of gardeners is so erroneous and so opposed to nature, as often to exhibit the great absurdity of endeavouring to produce an effect by removing the cause: we cannot therefore be too minute and particular in our attention to this part of the subject.

Q. Does not a plant originate in the seed? if so, suppose you begin by describing the first impulse given to the seed, and then trace it from its first development and transformation into a plant, to its attaining the state of maturity.

A. The seed is undoubtedly the origin of a plant;

but the seed itself is likewise originated, and it is at the origination of the seed that the future character and peculiarities of the plant are determined. At the time of the formation of the seed in its appropriate compartments, or of its being impregnated with the living principle, it is endowed with certain properties and peculiar characteristics; and after this impregnation and endowment, we possess no power to change or alter its characteristic properties. We must therefore investigate the nature of this origin, and endeavour to comprehend those laws and combinations of principles which regulate and determine the formation of the seed, before we can exert any influence in the production of varieties, or effect any change in the character and properties, of plants. We know that the seeds produced by a plant, or even those produced by one blossom, do not always produce plants of exactly the same form, nor fruits, nor seeds, nor flowers, of the same colours and qualities; but that frequently every seed of the same family, however great the number, produces some variety; and as one variety often possesses more valuable properties than another, it must be desirable to exert the powers we possess of controling and influencing the process of nature in the formation of seeds, so as to be able to produce plants possessing those qualities that are most valuable to us. Those powers consist in the means we have of assisting nature, by administering to her wants and upholding those laws and principles which regulate and deter-

mine this part of the system of vegetation. The formation and production of the seeds of plants are performed by and within the blossoms or flowers; we must therefore first investigate the structure of the different parts of the blossom, and ascertain and understand their uses and office. In the course of the inquiry, we cannot do better than adopt the terms and descriptions, and observe the divisions and distinctions, used and established by the botanists.

In botany, the blossoms are divided into six principal and distinct parts, viz.; the calyx, the corolla, the stamens, the anthers, the pistil, and the nectarium. The calyx, or flower-cup, is that part of the blossom which forms its exterior envelope, on its first appearance as a bud; this, on the opening of the blossom, forms a cup or stand for it to rest on; in some blossoms it also forms a protection for the embryo fruit or seed vessels, after the petals or corolla are thrown off: this is the case with all stone fruits, such as plums, peaches, &c.; whilst in others the calyx is fixed upon the fruit and seed vessels, and placed on its outside, which is the case with the apple, pear, &c. But in all plants, the pistil is placed withinside the calyx, and joined to the seed vessel or fruit. The corolla, petals, or blossom leaves, are those delicately formed leaves, which are produced from withinside the calyx; these constitute the flower, and generally surround and inclose the pistil, stamens, anthers, &c. They are exhibited in a great variety of forms, and in all the beautiful

colours of nature; but some plants are without petals. The stamens, or stamina, generally placed round the pistil, are the stems or the supporters of the anthers or chives, which are placed on their summits; some of these being fixed as heads, others so slightly attached and suspended as to resemble drops, and to vibrate with the least motion; and the anthers, chives, or drops, produce and are covered with a light dust or powder, which is called the pollen or farina. The pistil is a tube, or congeries of tubes; the bases of which are affixed to, and open into, or communicate with, the embryo seeds, that are placed in certain chambers or vessels formed for containing the seeds, and these chambers are arranged and exhibited in different forms, by the different genera of plants, some forming pods, whilst some are contained within the pulpy substance of the fruit, and some in hard shells. At its other end or termination the pistil is furnished with a crest or crown, of a vascular or sponge-like substance, by some called the stigma; this is endowed with the power of attaching and retaining the pollen or powder, produced by the anthers. In some flowers, the pistil projects a great distance from the seed-vessels; in others it is so short that the crest or crown rests immediately on the seed-vessels or fruit. The nectarium consists of little cups or cells, which are formed at the base of the stamens and around the base of the pistil, and are surrounded and fenced in by the petals; and these

cups or cells are formed to secrete and hold a sweet liquid; this contains an essential oil, which diffuses the most fragrant perfumes.

Q. And are these different parts of the blossoms of plants formed for any peculiarly needful and distinct purposes?

A. Certainly: and although all the different parts enumerated are separate and distinct, and each part is formed for a peculiar purpose, they are arranged in such just conformation and order as to produce one essential object; to this end they are also made to act in unison and combination; and the design, orderly arrangement, and disposition of these different parts, as made by nature to support and assist each other, are always beautiful and perfect.

Q. What are the peculiar uses of these different parts of a flower, and what object do they concur in establishing?

A. The use of the calyx appears to be to envelope and protect the blossom during its infancy or whilst it is in the bud, and to support it when expanded; and with some plants, to encompass and sustain the seed-vessels or fruit, during and after the decay of the petals, and until they become inured to the climate, or until the season is sufficiently advanced and the weather sufficiently warm. The corolla, petals, or blossom leaves, do not appear to be of any other use than that of protecting the stamens and anthers, and possibly of secreting and securing the contents of the nectarium; but no doubt their

beautiful colours are also designed to allure and attract the notice of insects to the stores of the nectarium, which they surround.

The stamens are formed to support the anthers, and with them to secrete and furnish the pollen, or that substance which, in the form of a powder or light dust, is the medium by which the living principle is conveyed to the seeds; which powder, on examination by the microscope, appears to consist of globules, or eggs, each containing the rudiments of a plant. It is supposed that these eggs, being placed on the stigma of the pistil and exposed to the influence of the sun, are burst or hatched, and that the living principle being taken in by the stigma, which is furnished with little mouths for the purpose, is by them conveyed down through the tubes in the pistil, into the seeds, which are arranged ready to receive it in their appropriate vessels; and that thus the living principle is given to the seeds. This is not only probable, but we know, by actual demonstration, that unless some of the pollen or powder, be brought in contact with, and attached to, the summit of the pistil, the seeds will never acquire the living or vegetative principle, nor attain maturity. It has also been demonstrated, that it is by the means of the pollen that the varieties in the plants raised from the seeds of the same plant, are chiefly produced; and the law of nature seems to be, that a plant shall alike partake of the characteristics, formation, and qualities, of the plant and blossom

which produced the seed, and also of that which produced the pollen; much in the same manner and degree that a young animal partakes of the colour, form, and nature of both father and mother. The pistil, as before observed, is a tube, or an accumulation of tubes, and forms the medium or channel through which the living principle, or rudiment of the plant, is conveyed to the seeds; and it appears formed for this use only; for as soon as its office is performed, it withers and dies. By what motion or impulse the living principle is taken in and conveyed by the pistil to the seeds, may be difficult to ascertain; but the crowns, summits, or ends of these tubes, are thus described by Dr. Hill:—"The stigma, or head of the style, which is the extreme part, or termination of the pith of the plant, viewed with the microscope, appears to be covered with prominent tubercles, and the centres of those tubercles open and form the mouths of so many tubes; these mouths are wide enough to admit with ease one of the minute rudiments of the plant, lodged in each egg or grain of the pollen." The lips of the mouths attach and retain the pollen, or eggs, whenever, or by whatever means, they are brought in contact with them; and being so attached, they are held and exposed to the influence of the sun, by which they are burst, or hatched, and the living principle is then received by the mouths, and conveyed by the tubes of the pistil to the seeds. It must be observed, however, that the pistil and seed-vessels, and the anthers

with the pollen, are not always united in one blossom; but in some kinds of plants the pistil and the seed-vessels, or fruit, form a separate and distinct blossom; and sometimes those parts exist without petals or flower leaves.

The nectar, or sweet liquor, secreted by the nectarium, appears to be formed for, and appropriated to, no other purpose than food for insects, and its perfume is diffused to attract them; in this respect it is calculated to produce the most important effects; for a plant being stationary, and it being absolutely necessary, in order to enable it to propagate its species, that the pollen or farina be brought in contact with the summit of the pistil, the means must be provided for effecting this conjunction. In these provisions of nature we see displayed a benevolence and delicacy of design, and such beauty and perfection of order and arrangement, as cannot be equalled by art, nor is excelled in any other part of the grand system of nature. We may consider the nectarium, then, as formed to secrete and furnish food for insects, particularly for bees. These receptacles, or reservoirs of food, are placed at the foot or base, of the stamens that bear the anthers, and of the pistil, and the whole are inclosed by the petals, so that, to come at their food, the insects must pass over and between those parts; in so doing they brush the pollen from off the anthers upon the pistils, or gather the pollen about their heads and legs, which are covered with feathers or bristles in

every respect suited to the purpose, and with these they convey it from the anthers to the pistil, either of the same blossoms, or carry it from one plant to another, when separate and at a distance. In this admirable arrangement we have a further instance of certain laws of nature being established for rendering animals and vegetables dependent upon each other; for thus plants are made to sustain insects, whilst insects in return are made needful and important agents to plants, in the propagation of their species.

Q. How is this knowledge to be applied to any beneficial purpose?

A. It enables us to take upon ourselves and perform the office of the bee; and thus, either to produce, or to prevent, the formation of varieties. If we are desirous of producing a particular variety, we may collect the pollen of such particular blossom or plant as we may choose, and convey it to any other blossom that may be selected; as the seed produced by such conjunction, is made to partake of the characteristics of both the blossoms, and of the other parts of the parent plants, and to combine, in a certain degree, the prominent features and properties of each; we may, by a proper selection and pairing, direct and promote the production of such varieties as we are desirous to obtain; and by preventing the conjunction of different varieties, or an admixture of one species with another, we may continue any particular species in its original characteristics and properties.

Q. Can you, by thus selecting and combining two blossoms, produce new flowers and fruits?

A. Yes, what may properly be called new fruits and flowers; but we cannot produce a new genus of plants; varieties of the same genus in colour, size, and general qualities, may be thus obtained at pleasure; and in some plants, in number beyond calculation, for all plants are not alike in this respect; in many, it is difficult to produce any variety; in some, perhaps, impossible.

Q. Will not one genus of plants blend with another?

A. Not in a general way; mules or hybrids are sometimes produced, but this may be considered as a sport of nature; it is a thing which seldom occurs.

Q. Does the production of all the varieties and changes in the form and qualities of plants, entirely depend upon the connexion of two or more blossoms of different plants?

A. Not exactly so; the quantity and quality of the food, and the nature of the climate, have, no doubt, great influence in determining the constitution and qualities of plants; but such influential circumstances must exist, and can only be effective at the time of the formation of the seed, or of the conjunction of the farina and pistils taking place. Seeds engendered by plants whilst they are under the influence of a luxuriant supply of food and a favourable climate, generally produce plants of extended bulk and capacities; on the other hand, seeds pro-

duced by plants that are stinted in their food and depressed in their growth by an ungenial climate, will produce plants of reduced capacity and bulk. But the plants that are raised from seeds produced in a hot climate, will be better enabled to endure that climate, than the same kinds raised in a cold climate, and *vice versâ*. Plants raised from seeds propagated in a cold climate, will endure a cold climate much better than the same kinds of plants raised from seeds brought from a warmer climate; and plants raised from seeds produced by plants under the influence of a luxuriant supply of food, will grow more healthy, and be more fruitful in a rich soil, or with a luxuriant supply of food, than plants raised from seeds produced in a poor soil, and with a limited supply of food; whilst, on the contrary, plants raised in a poor soil, and with but a scanty supply of food, will grow better in such soil, and prove more healthy and prolific than plants which were raised in a luxuriant soil, and transplanted into a poor one.

Q. When we wish to produce variety, and to obtain plants, fruits, and flowers, partaking of the qualities of two select plants, how are we to proceed?

A. Suppose, for instance, you have two geraniums, producing differently shaped leaves, and differently coloured blossoms; or two apple-trees, bearing apples of different sizes, colours, and qualities, and it be desired to produce geraniums of differently shaped

leaves and differently coloured flowers, and apples of different sizes, colours, and qualities, that is, different from either of the two plants or trees which you possess; the mode of effecting this is, to select a blossom of the plant from which you wish to obtain the seed; when it is just on the point of opening and exposing the anthers, take a pair of scissors, and, gently forcing open the petals of the blossom intended to bear the seed, cut off the stamens, and remove the anthers, and then leave the blossom thus operated upon for a day or two, or until the petals are quite expanded, and the pistil arrived at a state of maturity; when it is in this state, select a blossom of the plant with which it is desired to impregnate the prepared female blossom, and when this is in a state of maturity, and in a state to part with its pollen or farina freely, take a small camel's hair pencil, collect the farina on the point, and place it on the stigma or crown of the pistil of the prepared blossom. This operation may be performed, with an equal chance of success, on plants of all descriptions; but it may be necessary to observe, that, from the time the pistil of the prepared blossom is exposed until it begins to die away, it will be necessary to guard it against the approach of insects, for otherwise they may bring the pollen of other flowers, and deposit it on the pistil, and thus destroy the effect of the first operation.

Q. If the object be to raise plants, and flowers,

and fruits, of larger size and more luxuriant growth, how are we to proceed?

A. The most certain means will be to furnish a plant with a favourable soil and climate, and as luxuriant a supply of food as it can endure consistently with health and vigour; at the same time allow an ample space for its branches and leaves to expand and be exposed to the influence of the sun and the air, and protect it from being checked in its growth, or otherwise injured by the weather; you must take care also, that the blossoms intended to be preserved to produce seed, are properly impregnated with the plant's own pollen. As a general practice, and where it is difficult to interfere in coupling or pairing the blossoms, the finest and most perfect seeds, fruits, and roots, may be selected from the most perfect plants; raising plants from these, you should again select the seeds, fruits, or roots, and raise plants from them; and thus by persevering, and taking proper precautions against promiscuous impregnation, by bees and other insects, the greatest improvements may be made, and the good qualities of approved varieties, that are already established, may be continued and sustained.

Q. What precautions can be taken, and what means can be adopted to prevent the access of bees and flies to blossoms?

A. This must depend on circumstances and situations. When blossoms are selected and impregnated

by art, they may be surrounded by coarse gauze, or kept under cover of glass; but when it is required to raise seeds that shall be true to their kind only, it is best done by placing the plants at a great distance from others of the same genera, or by taking care that no others of the same genera shall blossom in their neighbourhood, or by planting such large quantities together, that the bees may satisfy themselves without going to other plants.

Q. Has the climate any great influence in determining the character of plants?

A. Perhaps not so much in changing the character as in determining the constitution. If you take seeds that are produced under the circumstances of a protection from cold, or the favour of peculiar warmth, and plant them in situations where they are without protection, and the climate is severe and cold, the plants will not thrive so well, but will probably decline and fail; on the contrary, where seeds that are produced in a wild state and an exposed situation, or in a cold climate, are planted under protection, or in a warm climate, and supplied luxuriantly with food, they will grow too rapidly to be healthy and vigorous; in either case, if the seeds which are produced in the new situation, are selected and planted for a few successive generations, the plants will become more enured to and naturalised in their new habitations.

Q. Are not plants improved in their qualities,

and varieties obtained, by grafting and inoculating one plant on another?

A. Although every variety of plants of the same genus, may be made to grow, one on the other, by grafting or inoculating, every graft and bud, although ten thousand times transferred from one stock to another, will invariably maintain the same characteristics, with which the mother plant was endowed at its birth or generation. But as one stock may furnish a more luxuriant supply of sap or nutriment than another, the plant and its produce of flowers, seeds and fruits, may vary in size, quantity, and quality; but still the peculiar characteristics will be essentially the same.

Q. For what purpose then, is grafting resorted to? Does not the operation render those plants fruitful, which would otherwise not bear fruit?

A. The operations of grafting and budding trees and plants are resorted to principally for the purpose of propagating and multiplying particular and well-known varieties, which, as they will not strike root from cuttings or layers, could not be done by any other means. Suppose, for instance, one hundred, or only two, nonpareil, (or any other variety of) apple trees were desired, they could only be obtained by grafting or inoculating other plants of the same genus, with the shoots or buds taken from a nonpareil, or such other fruit tree as it is desired to increase in number; they cannot be obtained from seeds. Only one nonpareil

tree has ever been raised from seed; only one golden pippin; and only one plant of any other sort of apple. The immense number of each variety which are in existence, have been all raised by grafts, originally taken from the same seedling plant. The natural tendency which some trees have to a luxuriant growth is also checked by grafting, for as they can have no other supply of food than is furnished by the stock, if the stock be of a more diminutive kind than that from which the graft is taken, the growth of the graft will be limited to the supply of sap furnished by the stock; hence, grafted plants will fructify sooner than the natural plants, because it is required by nature that plants shall attain a certain age, and a surface of branches proportioned to their supply of food, before they can fructify; and the graft being taken from a plant that is past that age, it will fructify immediately that it attains a surface of leaf proportioned to its supply of sap. It may be so managed by art, that the graft may be fixed on such a stock as shall produce no more sap than the proportion required; and thus the growth of the graft may be confined within a small compass, and be brought to fructify the season after grafting or inoculating. But, as before observed, the operation of grafting alone will neither alter the fruit nor change the nature, form, or growth of the plant or tree; nor can the branches of a seedling plant, by such means, be brought to fructify in less time than it may be made to do by proper management on its own native

roots; that is to say, a graft taken from a seedling plant will not fructify before it has attained the age assigned by nature, let it be fixed on whatever stock it may; and every seedling plant that is duly supplied with food, and placed in a genial climate, will, sooner or later, bear blossoms, seeds, or fruit, without being grafted or budded.

PART V.

EXPOSITION OF THE GENERAL STRUCTURE OF PLANTS, AND THE USES OF THEIR PRINCIPAL PARTS.

Q. The means of obtaining the seeds of plants having been explained, what is the best manner of disposing of them, so as to produce the most perfect plants?

A. Although seeds contain within them the future plant already organised, if the seeds of many plants are kept properly dry, the principle of life will lie in a dormant state for several years, and then, on being supplied with the proper stimulants, will become active. To give the necessary impulse to the living principle, or stimulate the seeds to action, a certain quantity of water, a constant supply of oxygen or fresh air, and a certain degree of heat are required: being supplied with these, the seeds will immediately imbibe the water and begin to swell and enlarge themselves; in a short time they will protrude a small root, or radicle; and in whatever position

the seed is placed in the earth, so soon as the radicle is protruded to a sufficient distance, it will assume a perpendicular position, and push itself downwards: and most seeds will at the same time also push the body of the seed upwards through the soil until it reaches the surface, where it will turn itself, so that the seed-leaves or lobes may expand, and expose their surfaces to the light and sun: after this, the germen, or embryo plant, will advance upwards into the air, and extend itself in leaves and branches, and the principal root or radicle, will throw out collateral roots or fibrils, and extend them in all directions through the earth, so as to establish the plants and procure a due supply of food.

Q. Will seeds grow at all times of the year? or are there particular seasons for sowing them? At any rate, are not some seasons more propitious to their growth than others?

A. As the required quantity of water, and of oxygen, or fresh air, and the requisite degree of heat, may at all times be furnished by art, seeds may be made to grow at all times and seasons; yet, as these requisites are seldom furnished by nature, except at particular periods of the year, those periods constitute the proper seasons for planting seeds that are to produce plants to be exposed to a state of nature.

Q. What are those periods or seasons of the year, that are most proper for sowing seeds in the natural soil?

A. This involves many objects, requiring separate

consideration; thus, we know that in summer it often happens that a due quantity of moisture does not exist in the earth; that in the winter there is seldom a sufficient degree of heat; that, consequently, seeds sown at these times cannot be expected to grow, unless those deficiencies are supplied artificially. We may, therefore, lay it down as a general rule for raising all kinds of indigenous plants, that it is best to sow their seeds at the times and seasons pointed out by nature, which are the periods when they become ripe and are detached from the parent plant. This will generally prove to be in the autumn, or the latter part of the summer; and at this time of the year there is generally a sufficient degree of moisture, and of heat, to ensure their vegetating, and a sufficient interval between the frosty and cold weather, to enable plants to acquire strength to endure it, when it comes: but to raise plants that are natives of a climate much warmer than that in which they are intended to grow, or such as cannot endure frost, the seeds had better be preserved, and sown in the spring of the year. From not understanding or not attending to those laws of nature, it is found difficult to convert arable land into permanent pasture, or to form a good sound turf for lawns, from seeds. Whereas, if seeds of the proper kinds of grasses were obtained, and sown in the months of August, September, or October, on land properly prepared, a good sward of grass would be produced by the following May,

sufficiently luxuriant to be mown as a lawn, or to be fed off with cattle: and thus arable land might be converted into pasture, or pasture into arable, with as much facility and as little loss of time and expense of labour, as the changing it from one crop to another of any kind.

Q. Can any interference of art with the natural growth of the seedling plants, be beneficial?

A. As in sowing many kinds of seeds, it is difficult to disperse them at equal distances; it is necessary when the plants are intended to remain in the seed beds, that they should be looked over as soon as they appear fairly above ground; and those which are intended to remain, which in all cases should be at least six inches apart, being marked, the superfluous plants should be removed. But if the seedlings are intended to be transplanted, this operation should be performed as soon as the plants are large enough to be handled, as the earlier they are removed the better; and in transplanting, it must be remembered, that the greater the distance proportioned to its growth allowed to each plant, the more perfect will it grow.

Q. Will transplanting seedling plants, influence their future growth in any important manner?

A. In some cases it will, particularly where flowers, seeds and fruits are more the objects of cultivation than a large bulk or mass of trunk branches and trees, as these objects will be materially forwarded by transplanting, for, as has been before ex-

plained, the finest and most prolific old fruit-trees have been found to be those which were growing in a shallow soil on a limestone rock, whose roots were consequently spread, and forced to grow in a horizontal direction; and as it is the nature of some plants to push the radicle or first root to a great depth in its original perpendicular position, and to form what is called a tap-root, transplanting or taking up and replanting those seedling plants of trees that are intended to bear fruit, even if they were taken up and again planted in the same place they were growing in, produces these beneficial effects, as it affords the opportunity of cutting off, or altering the position of the downright root; which will occasion the plants to throw out and form their principal roots in a horizontal position, in which direction they will afterwards be more inclined to grow.

Q. Does curtailing the roots obstruct the growth of a plant?

A. Yes; as the office of the roots is to collect and supply the food or sustenance of the plant, the curtailing of these must lessen the supply of food, and check the growth of the plant; besides, as plants have no other power of repairing the loss than by pushing out fresh roots, which requires a long time; and as during such time, particularly if it be much protracted, the bark and sap-vessels will shrink and become so rigid and inflexible, that when the roots are again produced, and they collect and supply the full quantity of sap; it will probably be

more than the old trunk can pass up into the branches, or that they can receive and dispose of; in this case the uppermost branches cannot be supplied with a sufficient quantity of sap to sustain them in their usual luxuriance; they will, therefore, be stinted in their growth, and the sap supplied by the roots will be forced out through some other channel from the trunk, and there form strong branches; and as these, if permitted, to grow, will afterwards consume and appropriate the sap, and form the leading branches, the entire form of the tree will be changed.

Q. If then, transplanting, and curtailing the roots, be attended with such consequences, how can it be recommended as a good practice?

A. The bark of seedling plants, from being young, is not so apt to dry and contract, as that of older plants; but if it should do so, and the fresh branches be forced out from the bottom buds on the restoration of the roots, the old stem may be cut off with very little loss; and in taking up large and old plants, care must be taken not to curtail the roots more than it is impossible to avoid, and this may be generally done so as scarcely to check their growth. If it be necessary, after trees are taken up, to keep them out of the earth for such a length of time, and so to expose them to the action of the sun and the air, as that the bark of the roots and branches becomes dry and shrivelled, such plants or trees should be immerged in water, both root and branch, for some days, or until the bark is properly

filled out and distended, before they are planted. If, as before observed, the roots are so much reduced as not to be equal to the supplying sufficient food to fill the whole of the sap vessels, and the bark, in consequence, becomes constricted, and the strongest shoots are forced out near the root, the old branches must be removed, and the young ones fostered up to form the future tree.

Q. By what means do the roots collect and appropriate their food?

A. The covering, or bark of the roots, appears to be a vascular substance, formed like a very fine sponge; by this the liquid is absorbed, and by capillary attraction, or some other inherent power, conveyed into the interior of the roots, and from thence, by an efficient ramification of vessels, it is conveyed up through the trunk or stem of the plant into the different parts, and there appropriated and disposed of in the formation of all its various substances; the superfluous part being thrown off as excrement.

Q. If the nourishment required to sustain a plant be taken into the system by the vascular or spongy surface of the bark of the roots, and from thence passed upwards in one direction without any return, how are the roots propelled downwards or sideways, and elongated?

A. This may be done without the return of the sap from the leaves; and that it is so, is evident, for if we take a plant out of the earth, cut away

all the fibrils of its roots, and leave it exposed for a time to the air and the sun, either with or without leaves, it will shrivel, and the bark will contract: after this has been done, if the plant be plunged into water, it will soon absorb enough to swell, fill out the vessels, and distend the bark. This proves that although a plant, during its growth, throws out and forms fresh fibrils, it does not necessarily follow that the fibrils are the only feeders, or, that the leaves return back the sap they have received to form the fibrils; and farther, if a cutting of a tree without leaves and roots, be planted, it will be found to protrude its roots, before it does its leaves. This then proves that the roots are necessary to produce leaves, but that leaves are not necessary to produce roots. It may therefore be concluded, that as the liquid nutriment is absorbed by the bark of the roots, the plant posseses the power of impelling the sap to pass—upwards, for its various purposes of forming and sustaining the trunk, branches, leaves, and fruit—and downwards, for the purpose of pushing out new roots and enlarging the old ones. This motion or power is also exhibited when plants are grafted; for a few weeks after tying the graft to the stock, if it be taken off and examined, or indeed at any time previous to its uniting to the stock, it be found that the sap protrudes itself equally from the lower end of the graft, and the upper end of the stock, making equal advances to meet and unite; when they are united, the graft will throw

out leaves, but not before. This also proves that plants are endowed with the power of propelling the sap both upwards and downwards, independent of the immediate agency of either roots or leaves; and we may consider those operations to be determined by those laws of nature, which we are not permitted to comprehend or define. It has been ingeniously suggested by Dr. Darwin, that every particular leaf and bud is connected with, and supported by, a particular root, which extends downwards throughout the trunk of the plant or tree, into the earth; and it must be difficult to prove that such is not the case: but this we can prove, that if it be so, the existence of the bud or branch is not necessarily dependent upon any particular root; nor is any root dependent upon any particular branch; for if we cut off any part of the roots, we find the same branches still continue to grow; and if we cut off one set of branches, we find those that remain supplied with the food that those which were lopped off would have received if they had remained, and proportionally extended, and whatever branches we may lop off, the same roots continue to grow.

Q. By what power, then, is the sap impelled forward through the trunk and branches; and by what means appropriated in the formation of the products of vegetables?

A. Various opinions have been entertained on this subject, and many singular doctrines have been

promulgated, such as,—that the motion of the sap is determined by gravitation,—that the sap is circulated much in the same manner in vegetables, as the blood is in animals—and that the sap is drawn up by the leaves, and being by them digested, and concocted, is returned and appropriated to the different purposes of the plant. Many singular experiments have been resorted to, to demonstrate the correctness of such doctrines; but the results have been so differently accounted for, and represented, as to leave the advocates of each theory involved in contradiction. As to the idea that the motion of the sap, or the direction in which it shall flow, is determined by gravitation, which doctrine has been promulgated and maintained by some of the most celebrated philosophers of the age *, a very slight observation of existing facts will show its fallacy. The flowing of the sap, in all erect growing plants and trees, will always be found to be vertical, or directly inverse to that of water; consequently, it must be impelled and determined by a power that acts in direct opposition to gravitation. For instance; in all erect growing trees the largest quantity of sap is found to flow into those channels that present the most vertical outlet nearest the root; and if at any time the position of those channels should be reversed, by bending a branch down from an ascending perpendicular position, and fixing it in a descend-

* Sir H. Davy, T. A. Knight Esq., and others.

ing perpendicular, the sap will not flow down the branch in any large quantity, but will force itself out through the bud that offers the most vertical outlet and channel at its base, and will there form a new branch, and thus appropriate its sap in the formation of another upright branch or stem; unless the point, or extreme end of the branch, thus fixed in a drooping position, be again turned up, and made to present a vertical channel at its termination, and which shall rise above the level of its base, thus forming an inverted siphon; as in this case, the bud presenting this vertical channel, will draw the sap down the branch, and form a leading shoot at the point almost as luxuriant as if the branch had not been bent down. As this power is precisely the inverse of the action of a siphon, it furnishes full proof that the power which impels the movement of the sap, is directly opposed to gravitation, which determines the movement of water; and it may be farther observed, that if the flow of the sap in plants and trees was determined like that of water, by gravitation, it would, like water, find its way, and flow in the greatest quantity, through those openings that occupy the lowest position, and the branches would run along the surface of the earth; hence all plants must grow trailing, and thus the ends of nature be frustrated. In creeping plants, or climbers, such as the grape vine, the greatest flow of the sap will always be through the most distant buds, or those that are placed nearest the end of a branch,

whether the position of the branch be perpendicular or horizontal; and the strongest shoots will always be projected from those buds which are the nearest the end of a branch, whether it be shortened to six or less inches, or left the length of six or more feet, provided it be duly ripened to this length. It is therefore obvious, that if the motion of the sap in erect growing trees, could be traced to any known principle of action, such principle could not apply to creeping plants or climbers; consequently, we can only come to the just and obvious conclusion, that Nature, in all her ordinations, has suited her means to her ends; and that as in these, and all other cases, it is evident that the process of nature is regulated by certain laws, it is enough for us to know those laws, and to act in conformity to them. As to the idea that the sap of plants circulates in thém the same as the blood does in animals, we can form no notion of such a motion being continued without a heart and pulsation, or some such innate power; and no one has pretended to have discovered the existence of any such organisation in a plant. It may be said that a liquid may be passed upwards through tubes by capillary attraction, and downwards by gravitation; but having attained the summit of an upright tube, the liquor cannot be passed farther by capillary attraction, unless the tube is bent downwards; and in a plant the sap is continually impelled forward, to form fresh branches. It may farther be observed, that the same

functions of a plant are continued in horizontal branches, and a liquid cannot be passed in one direction by capillary attraction, and back again in a parallel and contrary direction, by gravitation; or in tubes placed on a level. Again, it may be observed, that although the position of a branch be invcrted, the same functions are continued, and the same offices performed. And as to the notion that the sap is drawn up by the leaves, and there concocted, and then returned back, we find that it rests on the supposed discovery of veins or vessels formed for the purpose; but, however great the authority of those, who represent such discoveries as correct, there are others of equal authority who contradict them. It may also be observed, that if the sap does circulate, the leaves cannot be necessary to maintain the process; for the action of the sap is continued during the absence of the leaves; and further, if the sap did circulate like the blood of animals, and the leaves had been necessary to sustain the process, as this circulation is continued the year through, they no doubt would have been made a permanent part of the plant, for we find every other process of nature fully and permanently provided for. In regard to the means by which the preparation and appropriation of the sap are conducted, if we can submit to the advice of that great and wise man, Sir Isaac Newton, which is, not to attempt to multiply causes, but to be content with one simple and obvious cause; we may rest satisfied

with the following theory. A plant has the power of selecting and taking in its nutriment by the roots, and of forming it into sap; and in this state, of impelling it upwards and downwards, either in a perpendicular, oblique, or horizontal direction, according as its necessities may require; a plant has also the power of decomposing the food or sap, and of apportioning and appropriating its various elements to its different purposes, and of expelling the superfluous matter as excrementitious, and the leaves perform the excretory functions.

Q. Is it demonstrable that plants possess such powers?

A. It is easily proved, that a plant cannot take anything into its body as food or nutriment, which is not in a state of liquid; it is also easily proved, not only that the menstruum, and the medium, by which the food of plants is prepared and conveyed, is water; but that the water itself contains the greater part of the elements of their composition. It is also proved, that plants have the power of decomposing water, and of expelling oxygen in the form of gas. This being allowed, then, and it being proved also, that all the produce, or the substance of plants, is composed of the same principles that are always contained in water, with the addition of carbon only, and that the various productions of plants differ only in the proportion of those principles; we have only to admit, that in addition to their general power of absorbing and decomposing

water, and the carbon which it holds in solution; the different parts or organs of a plant, like those of an animal, have the power of secreting and appropriating the different elementary principles of the sap, in due proportion to their wants, as it is brought in contact with them, and of passing on the remainder to the leaves; that all the superfluous oxygen is passed off as gas through the leaves, and that all the hydrogen and carbon, that is not wanted for other purposes, is appropriated by the leaves in the formation of their substance, and annually thrown off with them as excrementitious; and then we shall have no occasion to look for more extensive or mysterious powers.

Q. Can a plant appropriate all the food it consumes, except oxygen, to the formation of its various productions?

A. It cannot be necessary that any other part of the food should be immediately expelled as excrementitious, as no injury can arise from any other part existing in too great a proportion, whilst a plant is in health, and possessing its full powers. But it may be concluded, from the extreme activity of oxygen, and the great changes produced by its combination with other substances, when in undue proportion, that if it exists in excess in vegetables, it must create disorder, which it is proved it does; for as plants give out oxygen only whilst they are duly exposed to the sun, when they are deprived of the influence of the sun for any length of time,

the oxygen must accumulate in the plant, which is shown to be the case by the leaves losing their dark green colour, and becoming first of a yellow green, and ultimately of a white colour; and whilst in this state, fructification is prevented. Next to oxygen, hydrogen forms the greatest proportion in the food of plants; and all of this elementary substance, and also of carbon, that is not appropriated to other purposes, is disposed of in the formation of leaves. In support of this conclusion, it may be observed, that whenever a plant is supplied with, and consumes, a large quantity of hydro-carbonate as food, it forms a large quantity of leaves, and as in the formation of its seeds and fruit, a large quantity of oxygen and carbon is required by plants: when this cannot be obtained but in conjunction with a very large quantity of hydrogen, a large quantity of hydrogen must be disposed of, before the carbon and the oxygen can be furnished in sufficient quantity, and left free; hence we find that the formation of the blossom buds must always be preceded, and the fruit accompanied, by a due surface of leaves. Further, to show that the chief use of the leaves is to regulate and apportion the supply, and to abstract and expel the superfluous part of the food, it may be observed, that having performed this office, which is done during the season of the largest consumption of food, the leaves are then cast off, and that when food is again taken up in due quantity, and leaves are again wanted, for the purpose of abstract-

ing, expelling and disposing of the superfluous matter, others are produced.

Q. If such then be the case, a plant cannot produce flowers and fruit without leaves; yet, is it not the common practice to cut away some, and to shorten other branches, to make those which are left more fruitful? and to remove the leaves to prevent their robbing the fruit?

A. It is so; and this practice of removing the leaves of plants and curtailing the surface of the branches for such purposes, exhibits another instance of the ignorance and absurdity of an artist's attempting to produce an effect by removing the cause; for whenever the leaves are removed as soon as they are formed, the buds at their foot-stalks will fail to produce blossoms; and, although the loss of the leaves, after the blossoms or fruit are formed, may not occasion them immediately to decline, it will ultimately prevent their attaining perfection and maturity. It can scarcely have escaped the notice of the most inattentive gardener, that when the leaves of the gooseberry and currant bushes are all eaten off by caterpillars, which is a very common occurrence, the fruit never attains maturity and perfection.

Q. Then if fruits and flowers are the desired objects in the management of plants, the leaves ought to be protected and fostered, instead of being removed?

A. Undoubtedly, and it will more frequently be

found that plants fail to produce blossoms and fruit for want of a sufficient surface of leaves and branches to appropriate and properly dispose of their food and sap, than from these being so numerous as to rob the fruit. As has been before explained, a plant will not fructify until it has attained a surface of leaves and branches in due proportion to the food it consumes; consequently, whenever a plant is supplied with a large quantity of food, it makes a large production of branches and leaves; but, however large such production, if it be not equal to the supply of food, it can produce no fruit, and therefore, in the common course of nature, time alone can make the surface equal to the supply of food. But although we cannot increase the surface of branches and leaves, so as to make them equal to the proper disposal of the supply of food, and thus bring them to an early state of fructification, we can limit and obstruct the supply of food; and thus, by reducing the quantity of sap, effect and adjust the required proportions, and by such means anticipate the effect of time. On these principles we find grounded all the different modes that are resorted to, to render gross or luxuriant trees, or particular branches of trees, fruitful, for by those modes the same effect is produced as by an increase of the surface of the leaves. For instance if a tree that has been growing luxuriantly, without bearing fruit, be deprived of its bark, to the extent of two-thirds of

the circumference of the trunk, the vessels of supply will be lessened and the flow of sap will be lessened or obstructed; and there being then no more sap supplied than the leaves are equal to inspissate, the tree will, in consequence, either the next or the following year, produce blossoms and fruit; or if a large branch that had never borne fruit be thus treated, this branch will, and from the same causes, become fruitful, although the other parts of the tree will continue unchanged; for the vessels which supply the sap being thus cut off, or reduced in capacity, the quantity of sap must be so much lessened as to leave the leaves a much less quantity to dispose of; and consequently they are thus made equal to the duty of properly reducing and disposing of the sap that is supplied for the purposes of forming flowers and fruits. If a luxuriant branch of a tree, that has been growing in a vertical position, and has been too luxuriant to bear fruit, be brought down and fixed in a horizontal position, it will become fruitful, and from the same cause, for the sap will no longer flow in such quantity into that part of the branch; but, as before observed, a large portion will force its way out at the bud which offers the most vertical position at its base and there form another branch, and more leaves; and as in the former case, since the horizontal branch will then have no more sap to prepare and dispose of than the leaves are equal to appropriate, this branch will become fruitful. It may further be

observed, that when trees that are old enough but which have been growing too luxuriantly to produce fruit, are taken up and transplanted, they are generally brought to blossom the next or the following year. From these effects, indeed, we may conclude that the laws of nature which regulate the digestion and the concoction, or preparation, of the sap of plants, bear a close analogy to those which regulate and determine the evaporation of liquids for the formation of crystals, which has been before explained.

Q. Are we to conclude then that a plant cannot, under any circumstances, be furnished with too many branches and leaves to bear fruit?

A. If the branches are equally grown, and placed and disposed of in due order, and so that the leaves are exposed to the light, there cannot be too many leaves; but it frequently happens, particularly with plants that have been for some time pruned after the old fashion, that their branches are exceedingly unequal in their growth and forced to grow close together, and their leaves are consequently so crowded that they are deprived of the light, and the buds are so much overshadowed, that any flowers, or fruits, which they may occasionally produce, are thus rendered imperfect; under such circumstances, therefore, it must be necessary to remove great part of the branches and the leaves. But such operations are more frequently called for to remedy the blunders and the ignorance of the gardener than *to correct* the order of nature.

Q. When the fruit is overshadowed by the leaves, is it not retarded in ripening, and deprived of colour and flavour?

A. No; not exactly so, for although an exposure to the sun gives the fine colour to fruit, and sometimes increases the poignancy of the flavour, a shelter from the cold winds is equally necessary to enable the fruit to attain its full size and mellowness of pulp; and, therefore, fruit which has been ripened under shelter of the leaves is often of superior size and flavour to that which was exposed. However, the better plan is, so to dispose of the branches and leaves as to obtain the advantages of both circumstances, which, with a little attention, may generally be done: thus, in pruning and training trees, the branches should be so placed as to admit of their full growth, without crossing each other, and overshadowing, or being overshadowed. In transplanting, plants should be allowed a distinct and clear space around them, in every way equal to the natural expansion of their leaves, which will more particularly be explained hereafter.

PART VI.

OF THE DISEASES OF PLANTS.

Q. FROM what has been explained, plants do indeed bear a close resemblance to animals; and in being subject to diseases, the resemblance is continued still further. But do the diseases of plants vary in their effects the same as those of animals? and are they as easily discovered, prevented, and cured?

A. Yes: plants bear as close an analogy to animals, in being exposed to the injuries of disease, as in many other respects; and although from being stationary, plants may be incapable of affording such direct indications of the existence and seat of disease, or of the immediate cause; observation and practical experiments enable us readily to perceive the evil, to trace it to its cause with great accuracy, and consequently to apply a remedy; and a knowledge of such causes is of such importance, that not only the preservation of a crop of fruit may often result from it, but the beauty and symmetry of plants, as well as their existence, in many cases, entirely depend upon it.

Q. But the diseases to which animals are subjected, particularly the human species, are so multifarious as to baffle the efforts of the most studious professors of medicine to prevent and cure them; if such be the case with plants, can it be expected that sufficient attention can be bestowed upon them to produce any important success?

A. True: the diseases to which the human species are subjected appear to be incalculable; but the greater part of these are the consequence of locomotion and irregular exercise, to which plants are not exposed, and a still greater part are produced by the influence of the mind over the body, or the excitability of the nervous system; to these, again, animals in general are but little liable, and plants not at all.

Q. We very commonly hear of plants and trees, as also their flowers, seeds, and fruits, being injured and destroyed by blight; but not of plants being injured by disease: is this not a singular doctrine?

A. That plants are subjected to disease, is not a new discovery; but the causes and nature of the different diseases have not until of late years been investigated or understood. In ignorance of these, all diseases were comprehended in the term blight; and blight was considered to be solely the effect of atmospheric influence, or to be produced by some uncontrollable process of nature; therefore, although blight is a term in very common use, it is not easily defined. Whenever a plant, or any part of a plant,

suddenly fails in its growth or produce, and the cause is not immediately apparent, it is said to be blighted; thus, if the leaves, branches, blossoms, or fruit, are prematurely cast off, from whatever cause, the tree is said to be blighted; if it be injured or destroyed by insects, it is said to be blighted; again, if from water stagnating about the roots, the plant sickens, or if from impure food it gums and cankers, it is said to be blighted; in fact, in all cases of failure, blight is the assigned cause; so that to attempt explaining, or applying any particular remedy to, blight, must be ridiculous and absurd.

Q. Animals possess the means of making known the nature and seat of disease in various ways, by evincing painful and distressed feelings; but plants possess not this power: how then can you discover the nature, the seat, or the cause of disease in them?

A. Plants certainly cannot call our attention to their diseases, by the expression of painful feelings; but the indications of disease in plants are as perceptible and evident to the eye of a careful observer, as those of animals; and accurate investigations, and repeated experiments, enable us to arrive at very correct conclusions, as to the nature and causes of most of the diseases of plants.

Q. Is there not great difficulty in understanding and applying the remedies, as they may be required for different diseases?

A. No: with plants as with animals, by tracing effects to their causes, we are enabled to draw aside

the veil of mystery and quackery, and thus to show that what are held up as a numerous variety of diseases, are in fact originated by one cause. By attending to the old axiom, "Remove the cause and the effect will cease," we shall find it easy both to prevent and cure what appears to be several diseases by one simple process; and in regard to our notions of a variety of diseases, we may apply to plants the observations of a celebrated surgeon on the diseases of animals, namely, that whatever local injuries they may be liable to, there is no such thing as local disease; that is to say, although local injuries, such as lacerations, contusions, fractures, and corroding ulcers may be inflicted and made to exist, and be often followed by debility, inflammation, loss of limbs, mortification, and even death itself; such local injuries are not the causes of the diseases, or of the inflammation or mortification: the causes are found to be previously existing, in the peculiarly unhealthy state of the sap, blood, and humours, or in what is called the habit of the body. The local injury merely excites the torpid humours or seeds of disease, brings them into action, and thus creates inflammation and mortification: in other words, those external injuries act like a match, which cannot of itself create any destructive explosion, for to effect this the powder must be previously deposited. Thus it frequently happens that when a tree is in an unhealthy state, and a wound, trifling in appearance, is inflicted, mortification takes place, and spreads by

slow degrees round the branch, until it has destroyed the sap vessels all round, when the branch appears to die suddenly; from the cause not being seen, the branch is supposed to be destroyed by a blast of lightning, or, as it is often termed, a fire blast, or struck with a blight, and the loss quietly submitted to. Whereas, if the wound be perceived before it has extended quite round the branch, the mortified part cut away, and the wound rubbed over with a little soot, the branch may be preserved.

Q. By what means is the state of health of plants and trees determined, or how is it discovered?

A. To explain this, we must again refer to the analogy that exists between plants and animals. Thus we know that scrofula, rheumatic distortions, scorbutic humours, &c. in animals, are diseases, and the effect of a disordered system; that an excessive indulgence in gross and stimulating food and drink produces a disordered system; again, that those animals that are frugal, and limited in their indulgencies to the consumption of simple and wholesome food and drink, are exempt from such diseases: and such is found to be precisely the case with plants. Hence then, when we see plants in the spring exhibiting blistered and distorted leaves and shoots, or cankering ulcers, and discharges of gum, or livid mortifying wounds; we may conclude that such effects are diseases, and that their causes are an excessive quantity of impure and unwholesome food, supplied by the means of putrefying

animal and vegetable matters placed in contact with the roots of the plants; or from the roots being immersed in stagnant water. Again, it is with plants as with animals: although there may be no immediate appearance of cankered or ulcerated sores, yet as the state of the blood in the one may be such, that, on the infliction of any wound, or on the occasion of any rupture, inflammation may be excited, and an acrid and wasting discharge produced, often followed by mortification and death; so may it be with the sap in the other; and as we know that a weak and unhealthy state of the system renders animals sterile, so it is with plants. Again, as with the human species, such an unhealthy state of body as results from excess is indicated by a red or florid complexion, and a weak and vitiated habit of body, by a pale and yellow colour and a soft and flaccid flesh, so it is with plants: the effects of an excess of gross and stimulating food, are shown by a dark green colour, and the effects of impure and nutritious food, by a yellow colour and soft and watery leaves and shoots.

Q. Are those conclusions the result of actual experience, or are they mere suggestions of the mind?

A. They are the result of long-continued observation and repeated experiments; but so evident is the truth, and so simple are the means of demonstration, that any persons may easily convince themselves, by establishing and also by removing the cause.

Q. As a preventive is better than a cure, what are the best means of preventing those diseases?

A. From what has been said on the nature and properties of soils, and the food of plants, it must be obvious that the health and prolificacy of plants depend a great deal on the structure and situation of the soil and subsoil, on the state and condition of the food furnished, and also on the times and seasons at which the food is administered. In order therefore to ensure a luxuriant growth, and a healthy and prolific condition in plants, we must when planting take due care that the soil be properly constituted, both as to its mechanical and its chemical qualities, and that the subsoil be so formed and placed, in quality and circumstances, as to prevent the stagnation of water about the roots.

Q. When those diseases appear, what is the remedy?

A. A local remedy will be found for the canker and ulcerated wounds, by cutting clean away the infected or mortified parts, and rubbing the place over, and covering it well, with common soot, mixed with water, as a plaster. But a recurrence of such ulceration, or mortification, in some other part of the plant or tree, can only be prevented by removing the causes.

Q. If the application of soot will cure an old wound, will it not, if applied to fresh wounds, prevent ulceration and mortification?

A. Yes: there can be no better application; but

it must be observed, that in the case of large wounds, or the removal of the bark, if the part be covered or bound over with cloth or brown paper, so as to exclude the effects of cold air, the new wood and bark will extend and cover and fill up the wounds, in much less time than if left uncovered; and when large branches of trees are lopped off or torn, if the stump be cut smooth and painted with soot and oil, it will prevent the part from rotting and injuring the trunk of the tree.

Q. How are the causes of the diseases enumerated to be removed?

A. If the roots are immersed in stagnant water, which may be easily ascertained by sinking a hole in the earth, it must be got rid of by draining, if possible; but if not, the roots must be drawn up, and again laid down horizontally, at a sufficient height above the water. Or if the stagnant water be at a considerable depth, or the subsoil be cold and unwholesome, and the roots are run into it, the deep-growing roots may be cut off; but if the cause be putrifying matter, buried in the soil, it mav be rectified by a supply of lime-water.

Q. But when there is no appearance of disease, and plants and trees are notwithstanding sterile or unfruitful, what is to be done to render them prolific?

A. If they maintain a luxuriant growth of leaves and branches, and do not fructify, it may be concluded that there is an excess of gross carbonaceous

matter in the state of hydrocarbonate, and a deficiency of oxygen; in this case a solution of nitre or potash, properly applied, will often remedy the defect. But if the branches are weak and deficient in stamina, which is indicated by the yellow colour of the leaves, the defect must be remedied by a supply of carbonaceous matter, either by placing dung, &c., on the surface of the soil, or by making holes in the earth, and pouring in solutions of decomposed animal and vegetable matter, as before directed. And if plants and trees are furnished with blossom buds, which however fall off in the spring, or if the blossoms remain and expand, and then fail in their impregnation and fall off, or if after the blossoms are impregnated and the fruit set, they fail and fall off, either before or at their kerning, it may be concluded that the habit of the tree is vitiated by inert or unwholesome carbonaceous matter in contact with the roots; in this case, a supply of a solution of nitre or potash will generally correct the soil, secure the fruit, and enable the tree to sustain and bring it to maturity.

Q. But if the cause of the blossom buds being cast off, or of the blossoms failing at or after impregnation, &c. be unwholesome carbonaceous matter in the soil—how is it that the buds and blossoms, and the fruit, are sustained in health in one or two stages of growth, and yet fail afterwards?

A. As has been explained, the food of plants cannot be available until it is dissolved in water and

brought in contact with the roots; and as it often happens, when lands are manured or supplied with dung in the usual manner, that the dung remains without being saturated with water for months together, it cannot during this time reach, and therefore cannot affect, the roots; but on a sudden supply of rain, it is then dissolved and carried to the roots in an excessive quantity; and as this occurs at the different intervals of the growth, or advances of the blossoms and fruit towards maturity, it produces its effects accordingly.

Q. Do not trees sometimes grow healthy, and continue prolific for years, and then become unhealthy and sterile; and this without any addition of putrifying matter to the soil?

A. Yes; and this is occasioned by the roots growing deep into the soil. It often happens that when trees are first planted, the roots spread, and collect their food near the surface of the soil, and as long as they continue thus the tree continues healthy and prolific; but as the direction or growth of the roots, is generally determined by the supply of water, if this lies at a great depth, which is often the case during dry weather in the summer, the roots delve to a great depth after it; and as, when the roots are there, they cannot get back again, they are in the winter immersed in stagnant water; consequently trees thus circumstanced often make a luxuriant growth in the summer, and the shoots are cankered and diseased in the winter, and die in the spring.

Q. Are not plants and trees often injured, and their blossoms and fruit destroyed, by frosts and cold winds?

A. Yes; but the injuries and the destructive effects of frosts and cold winds are not nearly so great, nor so frequent in their occurrence, as is generally supposed: the losses and injuries which have been explained to arise from disease, are from ignorance often attributed to frosts and cold winds; but the difference in the effects of those different causes is sufficiently evident to be at all times ascertainable by correct observation. Whenever the leaves, blossoms, or fruit are injured by frost, they appear as if they had been boiled, and turn black before they fall off. If the weather is so clouded that the sun does not shine out for three or four days together, and the temperature of the atmosphere is below 50° Farenheit in the hottest part of the day, the incubation cannot be perfected, and the blossoms cannot be impregnated, nor the fruit kerned, although there may be no frost, and in consequence the embryo fruit turns yellow and falls off. When the blossoms and fruit fail from unwholesome food, the appearance is much the same; in order, therefore, to be certain of the causes of failure, a gardener should always be correct and regular in his observations; and if he marks the state of the weather, by the thermometer, during the impregnation of the blossoms and kerning of the fruit, he cannot well be mistaken.

Q. May not those fruit-trees which are fixed *against* walls, be protected against the effects of frost,

and of those cold and cloudy days, by a covering or coping to the wall, to keep them dry, and by covering the trees with netting, or with the branches of other trees?

A. The effects of frost may be prevented by such coverings; but when the failure is occasioned by the absence of the sun, and by the low temperature of the atmosphere, it must be obvious that such coverings cannot make good the deficiency; besides, as by such means of protecting the trees, insects are protected also, such coverings will generally be found to be more injurious than beneficial. Although the peach, nectarine, apricot, and many plums, pears, &c. as well as grapes and figs, require a higher temperature to ripen them than the common atmosphere attains, they are enabled to endure the severest cold of our winters, unhurt, when properly inured to them, and consequently, as extra coverings during the winter beget a delicate and tender habit, trees thus circumstanced often fail when those more exposed do well. When, therefore, walls are so situated and formed as duly to absorb and reflect the heat of the sun, they sustain trees in a more healthy and fruitful state, and bring the fruit to greater perfection, when they are without projecting copings or ledges; as to coverings of netting, these cannot keep off the frost, nor increase nor preserve the heat of the atmosphere surrounding the blossoms, and are therefore of little service.

Q. Are there any other diseases, or injuries, of which plants and trees are susceptible?

A. Plants are much injured by being infested with insects, particularly by the aphis, or as it is sometimes called the plant-louse, from its partially resembling the louse which infests animals; and of lice there is so great a variety, that there appears to be a peculiar variety for every genus of plants. From the apparently sudden appearance of these insects, in great and overwhelming numbers, they are, by many persons, believed to be brought by the wind; indeed so prevalent is this opinion that it is not only held by the illiterate gardener, but has been entertained by some of our most learned professors of philosophy. Hence gardeners being led to consider it impossible to guard against such evils, or to remove or avert the cause of them, they are generally quietly submitted to, and suffered to take their course; and the injury and loss in consequence is often very great. Of late years however, an eminent natural philosopher has given the subject his particular attention, and he has discovered, and demonstrated by actual experiment and observation, that these little creatures are propagated much in the same manner as lice on animals, and that the rapidity of their increase and advance to maturity, and their extraordinary fecundity, are such, as sufficiently to account for their apparently sudden appearance, without recurring to the agency of the winds or to what is called blight.

Q. But if these insects are bred by parents, in the same manner as vermin on animals, they must be a long time on the plants to produce such numbers; how is it then that they escape detection?

A. Almost all the insect tribe undergo several metamorphoses or changes, both in their shape or figure, and in their actions and propensities, during the short period of their lives, which seldom exceeds a year; and such is the case with the aphis. We will therefore commence its natural history, by observing, that in the fall of the year, or at the end of the summer, the aphis is found in the form of an active little black fly. This is a pregnant female, oviparous, and moving with great celerity from leaf to leaf, and from plant to plant, to deposit its eggs, which it uniformly deposits on the embryo buds, at the foot-stalks of the leaves; and as the buds grow and enlarge, the eggs are inclosed in their coverings, and thus protected during the winter. In the spring of the year, as the bud opens, the egg is exposed to the influence of the sun and hatched; the insect thus produced, is at first very diminutive, but it grows so rapidly that in eight or ten days it attains its full size and powers, and here the wondrous works of nature are displayed: this insect is also a pregnant female, but unlike its parent, it is of a green colour, is viviparous, and, unlike all other animals, it introduces its progeny into the world the hinder parts foremost. In this manner it speedily gives birth to upwards of a hundred young ones;

all of these are pregnant females; and on attaining maturity, which they attain in the same short space of time as their parents, each of these proceeds in the same manner to give birth to an equal number of young ones; all of these, again, prove to be pregnant females, and proceed in the same manner to increase in numbers, and this is continued for ten generations successively, but at the tenth generation, a mysterious change again takes place; the young ones of this generation are males and females in equal numbers,[1] the males assuming the figure and colour of the former females, and the females, that of the little lively black fly, at first described: at this time the usual connexion takes place between the male and female; the females then quit the old colony to establish fresh ones, leaving the males and the old aphides smothered and dying in their own filth. Such then being the astonishing fecundity of these insects, we may readily account for their apparently sudden appearance; for we may suppose, that from the diminutive size, and distant points of residence, of the first generation of aphis, even a careful gardener may pass them unnoticed; and if each leaf is occupied with one aphis only, it will in about ten days propagate 10,000; in ten days more, 1,000,000, and multiplying in the same ratio, every ten days, for ten generations, we may easily conceive that a tree must soon be covered with them. The bite of this insect is so poisonous to

the plants, as to occasion the fibres of the leaves to contract and curl up, so as to cover and protect them; and their excrement covers the leaves and branches, and forms that shining and sweet substance called honey-dew, which so obstructs and destroys the functions of the leaves, as often to produce disease and death.

Q. If such be the nature of insects, there is indeed no necessity for the agency of the winds to convey them; but how are they to be kept off, and destroyed?

A. A most effectual antidote will be found in tobacco, applied either in powder, or by burning and smoking, as the aphis cannot endure either; but as these insects have the power of curling up the leaves and thus covering themselves, tobacco smoke will more readily find its way into their retreats: this, however, can only be applied effectually when plants are placed in a close chamber, or vessel; when they cannot be so inclosed, tobacco-powder, or common Scotch snuff, may be thrown among them by a spiral powder-puff; and if this be effectually done, the insects will in a few minutes quit their holds and fall to the ground. But as after this operation, many may be caught in their fall, and still lodged in the leaves, it will be necessary to give the trees that have been so dressed, a good washing all over; and if this operation be repeated twice or thrice, at intervals of three or four days, trees may be completely freed from the annoyance, and restored to health and vigour. It may appear to some,

that when trees are without fruit, the loss of their leaves is of little consequence, and that therefore it is not worth while to take the trouble of clearing them; but it must be recollected, that if the leaves are prematurely destroyed, the buds at their foot-stalks, which would otherwise have borne blossoms and fruit the following year, will fail altogether; besides, the insects that may be left, will furnish females in abundance to stock and destroy the other trees another season.

Q. Do any other insects thus injure and destroy trees?

A. Not exactly in the same manner, but the larvæ of the moth and butterfly tribes materially injure and obstruct the growth of trees, and are therefore well worth consideration. These creatures, whilst in the fly state, commit no injury whatever to plants, as they merely partake of the contents of the nectarium of the flowers, which, as before explained, seems to be provided for the nourishment of insects; but the females of each kind, after impregnation, are directed by some peculiar instinct to select some particular plant, and on this to deposit their eggs; in the performance of this operation, each fly has its own peculiar manner; some deposit their eggs carelessly in the open space of the leaves; some place them carefully and with great regularity, so as to surround some small and young branch; whilst others, having deposited an egg on the point of a leaf, roll it up in a most ingenious manner, so as to form a neat and

compact little ball. But in whatever manner the eggs may be deposited, they remain dormant for a stated time, generally during the winter season. In the spring, as the sun restores the action of vegetables, the eggs are hatched, and give birth to a very small larva, caterpillar, or grub; these immediately commence their depredations, by feeding on the young buds and leaves; some of them penetrate into the interior of the young branches and roots, where they lodge and have the power of occasioning the sap to protrude and assume various forms to inclose them; such is the beautiful excrescence which is called the oak-apple, and the nut-galls; whilst others eat their way down the interior or pith of the young branch, which is thus destroyed; others make their way into the interior of the fruit and seed, and prey upon the kernel or farinaceous substance; but perhaps the greater number adhere to, and devour, the young leaves and shoots; and as it is these only that we can hope to catch easily, we must refer those who wish for a more minute description, to the study of entomology, and content ourselves with recommending the gardener to look carefully over his plants as the spring advances, and wherever he finds the larvæ, or caterpillars, to destroy them. There is one kind of moth, whose caterpillars, as soon as they are hatched, envelope themselves in a compact mass of web resembling that of the spider; these are generally affixed to the extremity of a young branch, and easily discovered and destroyed. An-

other kind have the power of drawing several leaves together and fastening them; these also are easily seen, if sought after, and readily destroyed by pressing the leaves in which they are enveloped between the fingers. The effects of those which penetrate the interior of the shoot, (these most frequent the apple-trees and currant-bushes), are first discovered by a small hole in the branch, or by the sudden withering of the shoot, which generally takes place at the point where the insect enters; this hole should be traced down the shoot by splitting it, and the insect destroyed; indeed, in whatever situation the larvæ are found, they should be destroyed. The smooth green-coloured caterpillars, striped with black, which infest the gooseberry and currant bush, are effectually destroyed by placing a large sheet of paper or a cloth under the bush, and then giving the trunk a smart blow; the shock will occasion them to fall on the paper or cloth, when they may be collected and destroyed. But as the larvæ fall to the earth in the autumn, and in this season change into the chrysalis state, and from the chrysalis state pass into that of the fly in March or April; covering the roots five or six inches with dung in the autumn, and forking and raking it off daily in April, has been found to destroy the chrysalis, and thus to save the trees from injury. There is also another insect, in the form of a small beetle, which infests the apple trees whilst in bloom; this creature making its way into the blossom, preys upon and destroys the

pistil and the anthers, when the fruit of course dies and falls off. Without any notion of the cause of this failure of the blossoms, but fully aware of the effect, and believing the loss to be occasioned by blight, the proprietors of some orchards in Wiltshire are in the habit of burning straw or weeds, dung, &c. under the trees when they first come into bloom, for the avowed purpose of preventing the blight; and it may be supposed that, as the smoke is disagreeable to the insects, it either kills or drives them away, for in orchards thus smoked, the fruit has been preserved, whilst those in the neighbourhood which were not smoked, have failed in their crops.

Q. It should seem then that the winds and the weather are but little concerned in producing the evils attributed to blight?

A. Not so much as is generally believed; at any rate, as before explained, the state of the weather has great influence on the productions of plants and trees, and often injures them in a way that cannot be guarded against otherwise than by artificial heat; but as regards the injuries to which those trees and plants, which are fixed against walls and blow early in the spring, are exposed, from sharp frosts, a preventive will often be found in temporary coverings by night. This is easily effected in the following manner:—Let a pole or plank be affixed at each extremity of the tree, and one in the centre of the tree, each standing about nine inches from the

wall and reaching to the full height of the tree; then, running a cord or wire through the upper and lower edges of a mat or cloth, fasten each end of the cord or wire to the poles or planks, so that the mats &c., may be drawn backwards and forwards like curtains on a rod. The coverings arranged in this manner require but little trouble to draw them before the trees in the evening and back again in the morning, and if they are fastened top and bottom the wind will be prevented beating them against the trees. When these curtains are drawn back and tied to the poles during the day, they will soon get dry after rains; and if from great exposure the wind is found to overpower the cords, others may be affixed and drawn midway, both before and behind the curtain. But, as before observed, the young fruit is so seldom injured by frosts, that unless such coverings are managed with great care and attention, the trees are more injured than benefited. Another insect, which infests plants, is so small as scarcely to be perceptible to the naked eye, nor does it eat enough of the leaf, shoot, or fruit, to destroy its figure or shape, yet by puncturing the vessels, or by some other operation, it deprives the leaves, branches, and fruit of their subsistence; thus, it not only obstructs their growth and prevents their attaining maturity, but disables the tree from fructifying during the next year. This insect is called the red spider, and by the aid of the microscope appears to possess the form and make of a spider. As it is

impatient of cold and wet, it is found to abound most in greenhouses and conservatories, and only in hot and dry summers without doors. Many remedies have been prescribed, but the most effectual has been found to be the washing the plants and trees, by a syringe, with water in which a little common salt has been dissolved; but in preparing this wash, great care must be taken not to use too much salt, or it will destroy the leaves: a teaspoonful of salt to a gallon of water will be as much as can be used with safety, and, to be certain that salt enough is not left on the tree to injure it, it will be well to wash it with pure water a day or two after the use of the salt.

PART VII.

RECAPITULATION—DIVISION AND ARRANGEMENT—OF THE LAWS AND PRINCIPLES OF NATURE, AS A FOUNDATION FOR RULES OF PRACTICE IN GARDENING.

Q. SUCH, then, being the laws and principles ordained by nature, for originating, governing, and determining the growth and productions of vegetables, are they not corroborated by such existing facts, as will admit of the deduction of certain axioms or rules, for the guidance of a gardener in the practice of his art?

A. Certainly; and it will be well to divide, explain, and reduce them to some such orderly arrangement, previously to entering upon an exposition of a system of practice. The chief object for which plants and trees are cultivated in the garden and the orchard, are their flowers, seeds, fruits and roots; our first care must therefore be, to bring them to, and sustain them in, the most perfect state of fructification. The leaves and stalks also being of considerable importance, both as objects of use and

ornament, the growth and disposition of these must likewise be regarded. Now, as for whatever purpose we may suppose vegetables to be created, it is clear that all kinds of plants and trees proceed by progressive degrees in their growth to attain a fructiferous state; and that in their advance from the seed to the attainment of their utmost size, the formation and arrangement of their leaves and branches are made conformable to the most perfect and symmetrical designs: the practice of gardening can be little more than the assisting of nature in the attainment of her ends, by supplying her with the required nourishment, and affording her support and protection against casual obstructions and injuries. To obtain the desired results of horticulture, therefore, our principal care must be so to regulate the operations of art, as that they may be in perfect harmony with the laws of nature: and as it is of the highest importance that these should be firmly imprinted on the mind, we shall first recapitulate and arrange the laws of nature to which the principal effects are traceable. They may be comprised under the thirteen following divisions:

1st. The generating, or first forming of a plant, or impregnation of the seed with the living principle, requires the junction of two distinct parts or productions of the blossom or flower; that is, it is required by nature that the pollen or dust produced by the anthers be brought in contact with, or placed on, the crown or summit of the pistil.

2nd. To enable the pollen to impregnate the seeds with the living principle, a certain degree of heat is necessary, according to the nature of the plant; some requiring a greater and some a less; but most plants require a degree of heat above 50° Fahrenheit's thermometer, when placed in the shade, and that the sun should shine on them for two or three hours, during some part of the day, for four or five days following, when in bloom, for the purpose of performing the office of incubation and hatching the globules which form the pollen. And it is allowed by nature that the pollen of one plant, when thus brought in conjunction with the pistil of another plant, although a variety of the same species, shall produce the like effect of impregnation; and that the progeny of the two plants shall in some degree partake of the peculiar characteristics of both of them.

3rd. To vegetate seeds, or give the necessary impulse to the living principle, and put it into action, a due quantity of water, and a due supply of oxygen, or a free access of the atmospheric air, and a degree of heat above 50° Fahrenheit, are necessary.

4th. Plants, like animals, require a constant supply of food to sustain them; and as from their peculiar formation, plants cannot consume or take anything into their bodies but in a state of liquid, water, holding in solution a certain portion of carbonaceous matter and earth, constitutes the nutriment or food

of plants; and a continued supply, change, or circulation of water in the soil, is necessary to sustain the life of plants, and to preserve them in health and vigour.

5th. Carbonaceous matter, when dissolved in water, combines with oxygen and hydrogen in different proportions; whenever oxygen preponderates in these compounds of carbonaceous matter and water, fructification is promoted and sustained; whenever hydrogen preponderates, plants grow more to leaf and stalk and branches, than to flowers, seeds, and fruit.

6th. The food of plants is taken up by the roots in a state of fluid, impelled upwards through the stem, branches, and leaves, &c., and diffused through the system; each part of the plant having the power of selecting and appropriating the portion adapted to its use; the residue, or that which is excrementitious, is thrown off by the leaves.

7th. The roots of plants are gradually propelled and extended into the earth, and there they continue to collect, absorb, and dispense an increased quantity of food, so long as it is supplied, and they grow unobstructed.

8th. The quantity and quality of the food supplied to plants, affect them much in the same manner as it does animals; that is to say, with a scanty supply of food they grow but little, and with a superabundant supply of food, they grow to the utmost extent of leaf, trunk, and branches.

9th. The leaves form the excretory organs of the plant or tree; and whether the supply of food be great or small, a plant or tree cannot attain or sustain itself in a perfect state of fructification, until it is furnished with a surface of leaves duly proportioned to the sap supplied by the roots. To enable them to perform their functions, also, it is necessary that the leaves should be duly exposed to the action of light, and to the influence of the sun and the air.

10th. In all erect-growing trees and plants in an open situation, and where the light falls equally, the sap is impelled in a vertical direction, or the inverse of the natural flow of water; that is, as water always flows in the greatest force through the lowest opening in a vessel or channel, the sap will flow in the greatest quantity into and through the highest opening, or that which is offered by the most vertical buds that are nearest the root. And the strongest and leading branches will grow in an upright perpendicular direction; but in places where the light has a partial access only, the sap will flow, and the branches bend, towards that side where the light is admitted. In creeping and climbing plants, the sap flows to the extremity of the branches, whether their position be horizontal or perpendicular, and whether such branches be long or short.

11th. The destruction or loss of any part of the buds, or young branches of a tree, will not prevent the growth and extension of the roots; but these

will expand, and the supply of food will continue to be taken up by them and appropriated to the restoration and reproduction of the leaves and branches.

12th. All trees are furnished with many more buds than they can sustain, to form fruit and branches; the position of the buds determines their office; those which occupy the most eligible situation for extending the branches, are formed for wood-buds; the others form fruit-buds, or lie dormant till wanted to form fruit-buds or to supply the casual loss of any wood-buds that were above them.

13th. If a bud formed and placed for a leading branch be removed, or its position be altered, or the vessels connected with it be contracted or injured, and the usual passage of the sap be obstructed, the wood-bud occupying the next best position will take its supply and perform its office. And when from any number of buds formed to receive a quantity of sap, a part be taken away, the share of sap which that part would otherwise have received is given to those remaining, and they are extended proportionally.

Q. Are the effects of cultivation in general determined by these laws? or are there particular laws ordained for the government and determination of the growth and production of particular plants?

A. These laws apply to the growth of all plants;

but as undoubtedly there are plants created to furnish all parts of the earth with vegetables, there are also plants adapted to almost every description of soil and climate, the growth and productions of which are determined by particular laws. As before observed, cultivation consists in supplying the natural wants of plants, and affording them protection against casual and local injuries and obstructions; in other words, of establishing the causes of the effects we wish to produce, and of removing the causes of the effects we wish to prevent: it will therefore be necessary for us, before we can undertake to cultivate any description of plants with any certainty of success, to obtain, besides a knowledge of general principles, a knowledge of the peculiar propensities and wants of such plants, and then to act in accordance with those laws of nature that are ordained for their support and supply. The first step therefore must be, to ascertain the nature of the climate and the soil, and the peculiar circumstances of the country in which the plants we wish to cultitivate are indigenous and flourish best; and next, their peculiar propensities and habits. Thus we know that many of the most beautiful and desirable plants and trees which are cultivated in this country, are natives of a warmer climate and adapted to peculiar situations; in cultivating such, it will be necessary to make good the natural deficiencies of the climate and the soil by artificial means; and as the

doing of this is attended with considerable expense and labour, it must often be desirable to reduce and limit the growth of such trees, so that they may be confined in their growth to as small a compass as possible, consistent with their health and prolificacy, for which purpose some must be planted in boxes and pots, others confined to walls, trellis, &c. The operations commonly resorted to for reducing and keeping plants and trees in this state, are called training and pruning.

Q. But although the growth and productions of vegetables are determined by certain fixed and immutable laws, established in nature, whilst certain plants and animals are formed to inhabit certain soils and climates, will not nature admit of an extension of or deviation from those laws? or how is it that new varieties of vegetables and their productions, as well as animals, are obtained of increased size and enlarged powers of endurance?

A. Nature is always inclined to promote the thriving existence of both animals and vegetables, and therefore, to a certain extent, will allow of an amelioration or change of habit, and will admit of the increase of certain propensities, which may be made necessary for the enjoyment of life, under casual circumstances. Thus, although she will not, as the poet has said, "temper the storm to the shorn lamb," she will temper the animal and the plant to the storm; but this change is not made, nor brought about in any great degree, suddenly, nor

abruptly, but gradually through each of several successive generations; whether animals and plants are transplanted from a warm climate to a cold one, or the contrary, or whether their supplies of food be lessened or increased, the progeny of parents placed under those circumstances will be made more conformable to such changes than their parents were; and thus by every fresh generation, their powers and propensities will be made more and more conformable to their condition, until they are become at least more (if not quite) equal to the full enjoyment of the situation and circumstances in and under which they are placed. For instance, when animals or plants that have been bred under very limited supplies of food, and are, in consequence, small in size, are transplanted into situations where the supply of food is in exuberance, they will, from their limited powers and habits, be subject to inconvenience and disease; but their progeny, produced under those circumstances, will be increased in size and powers, and thus be more equal to the due appropriation of the supply; the progeny of these will be again increased in size and power; and thus, by every succeeding generation, their size and power will be extended, until they have attained that which is required for the full enjoyment of the provision made for them. Again, if animals and plants that have been bred under the circumstances of a favourable climate and exuberant supplies of food, are transplanted into situations,

where the climate is severe and the supplies of food limited, they will decline in health and vigour; but their progeny, bred under those circumstances, will be less in size, and consequently the effect of privation will be less injurious; the progeny of those will be still less than their parents; and thus every generation will decrease in size, until they have attained the size and capacity best adapted to the circumstances and situation they are placed under.

Q. Then at this rate the crossing of animals or plants, by pairing those bred under the circumstances of an exuberant supply of food with those that are bred under contrary circumstances, and the reverse, cannot be productive of such benefits as result from continuing to breed from the same stock?

A. Certainly not, as the crossing will but beget a mongrel variety, in no way so well calculated for any particular soil or climate as that bred upon and in it. But it must be understood, that plants and animals have sometimes bad as well as good propensities, or such as reduce as well as increase their value; that when males and females possessing those good or evil propensities are paired, those propensities are increased in their progeny; therefore the only sure means of continuing or increasing the good propensities or properties of plants and animals, and of preventing or diminishing those that are evil, is by the exercise of a nice discrimination to make a proper selection when pairing: and as the powers of discrimination, in a requisite degree, are possessed

by few persons, it has become the general practice, for the purpose of avoiding the evil or obtaining the good, to continue to cross or change the seeds, or the breed, by pairing with males from the stocks of such as are known to possess those powers of discrimination, or from stocks bred under more favourable circumstances. But, inasmuch as this mode of proceeding is opposed to the course of nature, as before explained, although it may in some degree prove to be the means of avoiding one evil, it often produces another and a greater; that is to say, that although an increase of capacity, size, or peculiar quality may be obtained by crossing,—if the native soil and climate is not equal to sustain such an increase, artificial supplies must be furnished, or the plants and animals cannot be maintained in health and vigour; and the furnishing those supplies may be attended with expenses beyond the extra value obtained. And further, although animals and plants, and their seeds and fruits, are brought to attain a great size by exuberant supplies of food, they are generally depreciated in flavour and nutritious qualities.

Q. Cannot trees and plants be protected against the severities of climate, and at the same time regulated in their growth, and maintained in a fruitful state, by training and pruning?

A. Yes; but in the common mode of managing plants and trees, it is the practice to feed or manure, as well as prune, all kinds by the same rules;

and, as has been explained, since erect-growing trees and creepers or climbers, are governed in their growth by different laws,—and almost every genus of plants differs most materially in their natural propensities, and particularly in their mode and times of bearing, or producing their blossoms, seeds and fruits,—it must be obvious that no one particular mode of feeding, pruning and training, can be equally applicable to all: nor can any particular treatment, as to climate, be properly adapted to all kinds of plants and trees; consequently, before we adopt any particular mode of management, it must be necessary to consider and ascertain not only the nature of the native soil and climate of plants and trees, but also the peculiar habits and propensities, and the modes and times of bearing or fructification of every particular species of plant and tree we wish to cultivate.

Q. Then previously to explaining the application of those laws to any particular plants, will you not explain their general application?

A. Certainly. The first, second, third and fifth laws or axioms, are applicable to all plants; to the fourth and seventh laws there are some exceptions; but although these are recognised and acknowledged by all authors who have written on the subject of horticulture, as well as by all practical gardeners, it is evident by their general practice of manuring and enriching the soil previous to planting, that from the want of a due understanding of or

attention to those and the sixth and eighth laws, they are led to a misapplication of the means they possess, and hence, instead of facilitating the growth and advance of a plant, and enabling a tree to acquire the simple and elegant form intended by nature, and attain a state of fructification at an early period, they obstruct and retard it. For although, according to the sixth and eighth laws, a luxuriant supply of food produces a large and luxuriant growing tree, (which is necessary to produce and sustain a large and luxuriant crop of fruit;) by the fifth, eighth, and ninth laws, it is shown to be improper to furnish a more luxuriant soil or a greater supply of food than is required to produce and sustain the trunk, branches and leaves to the extent required to fill the space provided or allotted for it; for when a tree is forced beyond the bounds prescribed, it can only be reduced and adjusted to a due proportion by cutting away the superfluous branches; whereas, according to the ninth law, to enable a tree to produce and sustain a full and constant succession of crops of fruit, it is necessary that the sap supplied by the roots be equally distributed over the full surface of branches, so that all be of due and equal growth; and as it is well known that neither weak and stinted branches, nor those that are very strong and luxuriant, will bear fruit, it must be evidently necessary, to enable a tree to produce fruit, that the fifth law be observed, and the ninth law be sustained. By cutting out the

weakest and the strongest branches, according to the common practice, at the season of pruning, the appearance of a due equalisation of branches may be produced; but it is not so in reality, for in the succeeding year, according to the tenth, eleventh, twelfth, and thirteenth laws, the tree will be forced into the same inequality of branches as it had produced the preceding season, and it will therefore be necessary to repeat the same cutting and curtailing, to give it an orderly appearance. There can be no doubt that, notwithstanding the cutting and curtailing, a tree may be brought to produce some fruit, but nothing equal to what it would produce if trained more conformably to the laws of nature. As the cutting back and shortening a tree would be in opposition to the ninth law, it must be attended with a great waste of time, labour, and nutriment; and the beautiful and symmetrical form and growth of a tree, as designed by nature and capable of being produced by art, even when restrained within certain bounds, is sacrificed for the appearance of distortion, deformity, and decrepitude. And further, as many kinds of trees, such, for instance, as pear and apple trees, produce their fruit on shoots of one year old, and others on shoots of two or more years old, it must be obvious that, by shortening the young branches to two or three buds, these, according to the eleventh, twelfth, and thirteenth laws, are forced into the formation of wood-shoots, none being left to form blossom and fruit-

buds but perhaps a few collateral shoots; and although, in the course of time, trees thus cut back and shortened, may be furnished with a due surface of leaves and branches to bear fruit, these will be so crowded as to overshadow each other, and the fruit can never be perfect in size or flavour, which is particularly the case with pears, apples, plums, cherries, &c.

Q. But if it be required to confine the growth of a tree within certain bounds, can this be done otherwise than by cutting back and shortening the stem and branches?

A. As before observed, the only certain mode of preventing an effect, is to remove or to prevent the establishment of the cause; and the only certain means of producing an effect, is to establish the cause. By the fifth and eighth laws it is evident that the cause of a too luxuriant growth of branches, is a too luxuriant supply of a peculiar kind of food; if, therefore, we withhold or reduce the food, we suppress and limit the growth and productions of the branches. And in accordance with the tenth law, by bending down the young branches, and fixing them in a horizontal, or in a drooping or inverted, position, we prevent the elongation of those branches, and thus confine their growth within a proper space, and at the same time allow them to acquire a due age to produce fruit; by such means, we also facilitate the establishing of such a surface of branches and leaves, as are conformable to the ninth law, and

requisite to enable a tree to acquire the full powers of fructification.

Q. By what means can we ascertain that the soil is too luxuriant or too sterile, or deficient in any necessary principles of nutriment?

A. There is no certain rule for calculating exactly the capacity of any peculiar soil; but by what has been explained of the nature and composition of soils, we may be enabled to form a tolerably correct judgment of its general qualities; by repeated observations, and by the descriptions given, we may form some idea of the size a plant or a tree of any particular kind will attain, under circumstances of an exuberant supply of food, and a great depth of soil; and hence, when preparing a soil for planting, we may pretty accurately apportion the depth of the soil to the size we wish a plant or tree to attain, and the space we wish it to fill.

Q. Will trees thus checked and limited in their growth produce fruit so large and perfect as those which obtain an exuberant supply of food from the natural soil?

A. Yes; for although, according to the fifth law, a luxuriant supply of a peculiar kind of food will furnish a luxuriant growth of trunk, branches, and leaves, a luxuriant growth of branches is opposed to a luxuriant crop of fruit, unless, according to the ninth law, there be an ample space allowed for the expansion and exposure of the leaves and branches; for, without this, the food cannot be decomposed and

prepared, nor can its elements be apportioned and secreted for the production of fruit; but if a tree be furnished with a surface of leaves and branches, duly proportioned to the sap furnished, conformably to the ninth law, it will, although small, produce fruit of the finest quality; but for this purpose, not only the quantity of the food supplied must be proportioned to the size of the tree, but, according to the fifth law, the quality must be suited to the object, and it must be supplied at the proper season of the year. However, a small tree cannot, of course, equal the productions of a large one in quantity; if, therefore, when planting fruit trees, we are desirous of producing large trees, we must allow them an ample space and supply them plentifully with the proper kind of food, and be content to permit them to attain a greater age before they produce fruit.

Q. But whether a tree be permitted to grow on the largest scale, or be limited to a certain space, must it not be regularly supplied with a due quantity of nutriment?

A. Undoubtedly: but to appreciate the effect of what is understood by a luxuriant supply of food, we must attend to the fifth, eighth, and ninth laws; the existence and the operation of those laws and principles are clearly demonstrated by plants and trees in every situation; and whether they are directed and influenced in their growth by art, or left uncontrolled to nature, those laws are equally immutable. A constant supply of food is required to produce,

maintain, and mature a large quantity of fruit; but such food must be furnished at a proper season; according to the fifth law, it must be of a proper quality, as well as quantity, and, according to the ninth law, the plant must be enabled properly to appropriate its food.

Q. How are we to know whether oxy-carbonate or hydro-carbonate preponderates in the soil?

A. If a plant grows rapidly, but produces weak and delicate shoots and leaves, which assume a yellow colour, this indicates a want of carbon. If it grows luxuriantly of a dark green colour, but does not fructify, or if it produces blossom-buds, but these buds or blossoms fall off, it shows that there is a superabundance of hydro-carbonaceous matter, and a deficiency of oxygen.

Q. It appears that carbonaceous matter is supplied by the decomposition of vegetable and animal matter; but how are we to avail ourselves of a knowledge of the fifth law? How can oxygen or hydrogen be made to preponderate?

A. Hydrogen may be abstracted or lessened by the addition of lime, and, as before observed, a deficiency of oxygen may be made good by an addition to the soil of a solution of potash, or nitre, or oxy-muriatic acid.

Q. But will a supply of those substances produce the effect on plants that is stated to be produced by oxygen?

A. Yes. When two peach trees have been grow-

ing together under the same circumstances, both being furnished with an abundance of blossoms, and one of them has been supplied with a solution of nitre, and the other not, the one to which nitre was given, set, kerned, and brought to maturity a very large crop of fruit; whilst the other tree, to which no nitre had been given, threw off a great part of the blossoms; a great part of the little fruit which it had set, fell off at the kerning, or stoning, and the little which remained was inferior in colour and flavour. A geranium plant also, to which diluted oxy-muriatic acid had been given, produced eighty pods of seeds, whilst other geraniums, growing alongside, produced but few seeds; and some melon plants bearing a sickly appearance, whose fruit was turning yellow and failing, on being supplied with oxy-muriatic acid, immediately assumed a healthy appearance, and set and brought fruit to perfection.

Q. How, and in what quantity, is the oxy-muriatic acid to be given?

A. A tea-spoonful in a gallon of water, applied in the usual mode of applying water.

Q. But if, as has been stated, nitrogen is poisonous to plants, and produces disease, will not nitre when given to plants produce this disease?

A. If too large a quantity of nitre be given, or the application be too often repeated, it will produce gum and the disease of blistered and distorted shoots and leaves, and will occasion many of the fruit to fall

off; but if the diseased leaves and shoots are removed, the tree, having thrown off the poison, will afterwards mature the fruit that is left, and a supply of healthy and luxuriant branches and leaves will be produced.

Q. You say that the food must be supplied at the proper season; then does not the food produce the same effect whether supplied at one season or another?

A. If liquid food in excess be supplied immediately after the falling off of the leaves, or during the spring, it will incline the trees to throw out a luxuriant supply of wood and retard the formation of fruit-buds, or to cast off any fruit-buds that are formed; for these reasons, food should not be supplied at this season, when the production of fruit is the object. But if, after the fruit is kerned, which will be about midsummer, a due supply of liquid food of a proper quality be given, it will sustain the fruit and enable the tree to bring it to the utmost size and perfection, and at the same time promote the formation of fruit-buds for the following year.

Q. Are there any laws which determine a tree to throw out branches where they are wanted, so as to fill the lowest part of a wall or trellis, without cutting back or shortening the trunk and branches?

A. Yes; the tenth, eleventh, twelfth, and thirteenth laws determine the means: according to the tenth law, if a branch of an erect growing tree, be

growing in a vertical position, the sap will flow to its point, and the strongest branches will form there; but if it be brought down, and fixed in a horizontal position, the sap will no longer flow to its point in such quantities, but will form itself fresh channels through the bud that offers the next most vertical position at its base; by the same law, if a branch be fixed in a diagonal position, so as to form an angle of about 45°, the sap will flow into all the buds on the upper surface, and form branches of nearly equal size; and as, according to the tenth law, the sap flows in an inverse direction to that of water whilst the branches are in a natural position, so will it when the branches are bent like an inverted siphon; for, however low or declining the centre of the branch may be fixed, if the point or end of the branch be turned upwards, the point-buds will form shoots, which will draw a due supply of sap from the roots, to produce and sustain luxuriant shoots in an upright position; and if we rub off all the buds that grow where they are not wanted, in conformity to the thirteenth law, the whole of the sap will be appropriated to the support of those branches which grow where they are wanted, and all the food consumed by the roots will thus be profitably disposed of. A tree thus managed, conformably to the ninth law, will fructify at an earlier period, and in a more perfect manner, than when the trunk and branches are cut away.

Q. According to this doctrine, then, trees may

be trained so as to fill the space alloted them without the use of the knife?

A. So far as preventing the production of branches where they are not wanted, this may generally be done without the use of the knife; for by rubbing off, in the spring, all the buds which shoot out in places where young branches are not wanted, cônformably to the thirteenth law, the sap which those buds would have consumed in the formation of branches, which from not being wanted, must have been cut out at the winter pruning, will be appropriated to the support of the branches which are growing where they are wanted; and, therefore, by this mode of management, there can be no want of the knife to cut out superfluous branches; but as some fruit trees bear their fruit on shoots of the last year's growth, such as peaches, nectarines, &c., and as the branches will, in the course of time, extend beyond the bounds allotted, the use of the knife will occasionally be rendered necessary, to cut out the worn out branches, and to shorten those that are growing out of their proper bounds. Casual failures and accidents may also frequently require the knife; but these things will be more minutely explained, when we treat of the pruning and training of the different kinds of fruit-trees.

Q. Will not the cutting away and diminishing of the leaves and branches increase the size of the fruit?

A. In some cases, and to a certain extent, it may;

thus when trees have been left to grow in a wild manner, as they then throw out many useless branches, which not only smother the fruit but consume the nutriment to waste, a removal of these must benefit both the present and future crops of fruit. But when trees are properly looked over in the spring, and all superfluous and useless buds are removed, such operations will seldom be found necessary; sometimes, however, branches will extend themselves farther than can be required either for the present or future year; and some may be found of so great a length, as to be too weak to support themselves; these, therefore, must be shortened. There are some plants also that, according to the twelfth law, produce many more blossom-buds than they can sustain so as to become fruit; if the branches of these are suffered to grow to their full length, the fruit will form only at the extremity of the branches; when this takes place, the lower buds, from being overshadowed, will die away; and thus a tree may extend to a great distance, and not bear any more blossoms or fruit than when the branches are shortened; here again the knife may be beneficially employed, which will be fully explained when we treat of those plants and trees, to which such a practice particularly applies; but the leaves must in no case be removed from the branches, as, according to the ninth law, they are not only necessary to the due digestion and appropriation of the food, but shelter and protect the immediate crop of fruit, and prepare the

buds for succeeding crops. The rays of the sun, undoubtedly give the beautiful colour to fruits, and heighten the poignancy of their flavour; but the rags should be admitted without destroying the leaves; for fruits require a protection from occasional cold as much as increased heat; consequently, fruit growing on the branches that have been deprived of their leaves, will be inferior in mellowness ana size to those growing under the protection and support of the leaves.

Q. Although the sap supplied by the roots be disposed of, so as to produce an equal growth of the branches in a tree; may not such a tree, if left to itself, produce more fruit than it can sustain to maturity?

A. Certainly; and according to the twelfth law, there is seldom a season that some trees do not produce more fruit than can be brought to maturity; it is therefore proper to reduce them in number: but although there cannot be a greater fault, than the permitting too great a number of fruit to remain on a tree to ripen, it is a folly to reduce them below the proper quantity. The great object should be, to allow a due space between the fruit, that is to say, each piece of fruit should have a space sufficient for it to attain its full size, without touching or pressing against another. When fruit is thus equally distributed at proper distances, a tree will sustain a large crop, without being so much reduced or obstructed in its growth, as to be incapacitated from

bearing a crop the following year. Indeed, a tree bearing a moderate crop of fruit one year, will often be in a better state to produce a crop the next year, than a tree that bore no fruit; for when trees bear no fruit, the sap is appropriated in the production of luxuriant branches; and a tree of luxuriant growth is as incapable of bearing fruit, as a tree in an impoverished state. A moderate crop of fruit, by taking up great part of the food, keeps the growth of the branches within proper limits, and by preventing the formation of midsummer wood, a tree is inclined more to the production of fruit buds, than wood buds, for the following year. The ninth law applies equally all plants; for none will attain to a perfect growth that have not a space allowed, equal to the full spread of their leaves and branches. And the growth and perfect maturity of flowers and fruit, and also of bulbs and tubers, are determined by the same laws.

Q. You say that the quality of the food must be suited to the object, when it is supplied to plants and trees; how are we to understand this?

A. Yes, agreeably to the fifth and the eighth and ninth laws, the quality, as well as the quantity, of food, has great influence in determining the growth and productions of plants and trees; and in accordance with chemical principles, and practical demonstration, this may be explained as follows: when animal and vegetable matter is buried in the earth, or immersed in stagnant water, the greater part of

the carbonaceous matter is combined with, or held in solution by, hydrogen, thus forming hydro-carbonate and carburetted hydrogen gas, and when left to decompose on the surface of the earth, it is combined with, and reduced to a soluble state by, oxygen; thus forming oxy-carbonate. Experience proves that, whenever animal and vegetable matter in a putrescent state, is buried in the soil about the roots of plants, they extend their production of leaves, and increase in bulk, whilst fructification is retarded and prevented; and whenever carbonaceous matter is placed on the surface of the soil, and there suffered to remain to decompose, before it is brought in contact with the roots, these run horizontally and near the surface, and the trees and plants do not so rapidly extend themselves in bulk, but are healthy and vigorous, and fructification is produced. This being the case then, it must be concluded, that, in order to produce and sustain a large bulk of trunk and branches, hydro-carbonate must preponderate in the soil; and that, to produce and sustain fructification, oxy-carbonate must preponderate in it; therefore, in planting trees and plants, if a large bulk of trunk, branches and leaves be the desired object, the soil should be fully charged with matter which produces a due supply of hydro-carbonate; and when planting trees for the purpose of obtaining flowers and fruit, the soil should be so prepared as to contain, or admit of, a due supply of oxygen, or the soluble oxy-carbonate. On the same principles, when trees

and plants are found to grow too luxuriant in branches and leaves, for them to fructify, and it be desired to make them fruitful, this may be done by reducing the hydro-carbonate by converting it into oxy-carbonate, and which is to be effected, as before stated, by a supply of diluted oxy-muriatic acid. When, on the contrary, trees and plants are exhausted and impoverished, by producing more blossoms and fruit than they can sustain, the supply of carbon must be increased; which is easily done by a solution of blood or of thoroughly rotten dung, with potash, as before directed.

A

SYSTEM OF PRACTICE,

FOUNDED ON THE SCIENCE.

Q. ON commencing the Practice of Gardening, what is the first operation that requires attention?

A. Gardening comprehends the cultivation of Plants and Trees, for the production of leaves, flowers, seeds, and fruits; and it is usual to divide the subject into the five distinct compartments of the Pleasure Garden: the Flower Garden; the Kitchen Garden; the Orchard and Fruit Garden; and the Nursery Ground. Gardening in general likewise comprehends the mode and manner of planting and laying-out gardens and pleasure grounds, and of raising and planting forest and timber trees. But as these arrangements are more the objects of taste and convenience than of science, such a division of the subject, with a disquisition on each part, would be irrelevant to our present object, and be extending the work beyond the necessary bounds;

we must, therefore, leave such divisions and arrangements to be determined by circumstances, or to be taught by others. Gardening also comprehends many manual operations, such as digging, raking, hoeing, mowing, &c.; but as these are better taught by example than precept, we must leave the students to take advantage of the many opportunities that in all situations are presented, to make themselves acquainted with the mode of performing them. The operations of grafting and budding, or inoculating, and of propagating by layers, are likewise comprehended in gardening; but these also are more easily learnt, and better understood by seeing them performed, than they can be from any written instructions; and as nursery grounds are so numerously scattered all over the country, the opportunity of learning how to perform these operations is not only within the reach of every person, but from the care and attention necessarily bestowed by those who make it their business to raise plants and trees for the purpose of supplying gardens, these are more readily obtained from the nurserymen, and at less labour and expense, than they can be produced by private gardeners. We therefore need not enter into a detailed description of such operations; but having explained the laws and principles which constitute the science of Horticulture, we shall proceed to explain the operations and processes which are grounded upon them, and which are requisite to produce certain effects. For this purpose, we may

commence by supposing that the situation and elevation of the ground, as to climate and the capacity of preventing stagnant water, &c., are determined upon and arranged, and that the soil intended for a garden is prepared, and in the condition it ought to be; or, at any rate, we may presume that enough has been said to enable a person to make it so. The seeds and plants, also, being supplied, the first operation that will be required is the sowing or placing them in the earth. It has been before explained, that all seeds require a certain quantity of moisture, air, and heat, to enable them to vegetate or grow; therefore, the following rules must be generally attended to. Before depositing the seeds in the soil, it must be dug up or turned over, or at least the surface must be broken and pulverised and made as fine and even as possible, from one to nine inches deep, according to the nature of the seeds; for unless the soil be thus prepared, we cannot calculate upon the seeds growing with any certainty of success. If the soil be dry at the time of planting the seeds in it, as soon as the seeds are covered in, it must be beaten or trodden close down. The best method of sowing or disposing of small seeds in the soil is to form drills, by throwing out the earth in parallel lines, to the depth required; say from half an inch to three inches deep, according to the size and nature of the seeds; then, after depositing the seeds, to draw the earth evenly over them; and large seeds

should be planted or set at proper distances in rows or lines. This method of drilling and planting may appear too troublesome to be adopted upon all occasions; but in all cases it is calculated to save much future labour, and much difficulty will be avoided in performing the subsequent and necessary operations of clearing away weeds and thinning the seedling plants, or reducing their numbers, so that the plants may be at proper distances from one another. It will also afford the ready means of breaking or loosening the surface of the soil, by hoeing or otherwise between the rows, when it is baked or closed on the surface, after heavy rains; and this without injury to the seeds or plants. If it be required to plant seeds when the soil is very dry, the best method is to dig it up and water it, and to suffer it to lie a night after watering, before the seeds are sown, as it will then be in a state to pulverise more readily; the injurious consequences of pouring water on the earth after seeds are sown, and thereby closing the surface and excluding the air, will be thus avoided. As a further protection against the casualties to which seeds are exposed, when sown in hot and dry weather, it is a good practice to cover them with matting or loose straw of some kind, until the plants begin to appear on the surface of the soil, when the covering should be removed.

Q. The seeds being deposited, and the plants having made their appearance, what is the next operation?

A. This must be determined by the nature of the plants, and the object we have in view in raising them. If to obtain as large and luxuriant plants, in as short a time as possible, be the object, this will be best attained by permitting the plants to grow where they are sown, and not to transplant them; but if the early production of flowers, seeds, and fruit be the object, and the saving of labour be of little importance, it will be best to transplant the seedling plants of annuals, biennials and triennials, as soon as they have thrown out two or three pair of leaves; and those of shrubs and trees, the first winter after sowing; as by this operation the large and downright-growing roots will, or may, be curtailed, and horizontal ones encouraged, which are more adapted to fructification. But whether the plants remain where they are sown, or are transplanted, they must have a sufficiently clear space allowed between them to admit of the full extension of their leaves and branches, so that they may attain their utmost size without touching or overshadowing each other.

Q. But plants being of different growths and sizes, how are we to determine what space must be allowed to each kind?

A. As this must depend upon the state and condition of the soil, as well as upon the object for which they are raised, no exact space can be described as requisite for any particular description of plants; this can only be determined by experience and observation. It may, indeed, be observed as a general rule, that no plant which it is desired should attain the beauti-

ful and symmetrical figure designed for it by nature, and be healthy, vigorous, and prolific, should be allowed at the first stages of its growth a less space than the circumference of a circle of six inches diameter, taking the stem of the plant as the centre; and as the plants are found to require more room, more room should be made by the removal of all obstacles.

Q. But if so much space be allowed to each plant, are there not many kinds, whose productions in flowers, seeds and fruits in a given space of land, must be by such means much reduced?

A. None worth notice. There cannot be a greater error in the cultivation of plants—whether a large bulk, a handsome or symmetrical form, or the most perfect and extensive production of seeds or fruits, be the object—than crowding them too closely together; for, under such circumstances, they are not only starved, but, overshadowing each other, they are rendered unequal to the proper appropriation of even the little food which may fall to their share, and are drawn up into tall and thin stems, often too weak to support themselves, and are consequently unhealthy, imperfect, and sterile. But, although the practice of crowding plants close together is so egregiously wrong, there is perhaps none which more generally prevails. Undoubtedly, a greater number of plants may be obtained in a given space, by permitting them to grow close together; but neither the form and size of a plant, nor the quantity and edible *quality* of the plants, nor their flowers, seeds, fruits

or roots, can be so great, or so perfect, as when the plants are allowed a space sufficient for the full spread of their leaves and branches.

Q. How are plants so much benefited by so large a space of ground being allowed them?

A. The roots of plants spread to as great a distance, or extend themselves to as great lengths, under the surface of the soil, as the branches do above it; as, then, the growth of a plant will be in proportion to the quantity of food it consumes, and as, to enable a plant to fructify, it is required that it shall attain a surface of leaf and branches in proportion to the food it consumes, the good effects resulting from the allowance of an ample space must be obvious. Further, a plant is not only maintained in luxuriance by being protected from robbery, but, the surface of the soil being kept clear of weeds, it may be kept open also, by which the supplies of water, by percolation and capillary attraction, are regulated with greater uniformity; whilst, by the action of the air and the sun, the supplies of carbonaceous matter on the surface are reduced to a more wholesome state, and a more regular supply of nutriment is conveyed to the roots; and thus plants are more uniformly sustained in health and vigour, and rendered more prolific. When, too, a plant has room enough to grow unmolested and unobstructed, its branches are thrown out and arranged in the most orderly manner, to suit its wants, and to exhibit and maintain that perfect symmetry in form and figure which is always designed by Nature.

Q. But does it not frequently happen that a due space cannot be afforded, for a plant or tree to grow to the largest size? How then can we manage to apportion the surfaces of the roots and branches?

A. As we have before explained, it is frequently necessary, for many reasons, to check and confine the growth of a plant or tree within a given space; in cases of this sort, as we can always determine what space is to be allowed for the expansion of the branches and leaves, we must prepare the space for the range of the roots conformably thereto, and so that, in the same proportion as the surface of the trunk, leaves, and branches is limited, we may limit the supply of food. This may be done by various means, The most effectual is, to confine the roots in a pot; but we can also prevent the roots from growing deep, by placing an impervious substance at such a depth under the soil as may be equal to limiting and restraining the growth of the roots and adapting them to the purpose desired. Another mode of confining the growth of the branches within a convenient space is, to engraft or inoculate the large and wide-growing plants on the roots or stocks of those varieties of the same species that never grow large. The effect of this is exemplified by the practice of engrafting the peach on plum stocks, and the pear on the quince, &c. We can also so fix and direct the growth of the branches as to enable them to expose a large surface of trunk, branches and leaves to the light and the air, and at the same time to occupy but a small

space, which operation is called "pruning:" and when plants are found to grow too luxuriant, they may be checked, by taking them up out of the earth at the proper season, and replanting them.

Q. In the removal of seedling plants, or others, and transplanting them, is any particular care required, or any particular object to be attended to?

A. If it be desired to check the growth of the plant as little as possible by the removal, care must be taken that the roots are shortened, or lessened in number, as little as possible; and that the parts of the roots that are lacerated and torn be made smooth with a sharp knife. But that which, on transplantation, will have the greatest influence in determining the growth of the plant or tree, is the state and condition of the soil which is placed in immediate contact with the roots. If this be a stiff, wet and retentive soil, or a soil replete with putrescent animal and vegetable matter, it will frequently putrefy and destroy the roots; whilst, if they escape this, a close and stiff soil will obstruct and retard the formation and extension of fresh fibrils. To ensure the growth of a plant or tree, and forward its extension, with as little loss of time as possible, the most certain method is to take care that the roots are well covered with a thoroughly pulverised or sandy soil; that this be thrown lightly on the roots, and by no means trodden down, or forced close together; that no putrefying matter be placed within the reach of the roots; and that, at the same time

they be guarded against stagnant water, for when water stagnates about the roots after transplanting, they are apt to rot. When plants are kept out of the earth for so long a time that the bark is withered and dried up, they will of course require a liberal supply of water to revive and restore them; and with the view of supplying this, it is a common practice, on planting them, to pour as much water on the earth about the roots as will reduce it to mud; but this will produce the injurious effects before described. The best method is, to immerse the roots of such trees as are withered and shrunk in the bark in a tub or pool of water, for one or more days and nights, or for as long a time, previous to planting them, as may be necessary to swell out and fill the vessels of the bark and revive the leaves (if any), which will be seen by the shrivelled branches becoming plump and full or by the leaves expanding; and then to plant them, and cover the roots with earth, in a proper state, as before directed; if, after this, the weather should continue dry for any length of time, and the soil be dry, the plants must be frequently supplied with water, taking care not to reduce the soil to mud and thus close it, and also not to give a larger quantity of water at a time than is sufficient to saturate the earth with moisture to the full depth of the roots. The better way of supplying water at such times is, to make holes from four to six inches deep, at proper distances, and pour the water into these.

Q. Is it, then, of any consequence in what manner the water is supplied? Will it not produce the same effect, whether given one way or another?

A. The quantity of water supplied, and the method of supplying it, are objects of the greatest consequence. It is well known to be a generally prevailing opinion, that artificial supplies of water do as much harm as good; and no doubt the opinion is well founded; but this is because the water is supplied in a very improper manner, both as to the quantity and the mode of application. If as much water be given as will saturate the soil, and stagnate about the roots, it will rot and destroy them, which is readily proved by a pan kept filled with water, in which a pot that a plant is growing in is placed; and if water be poured from a great height on the soil, it will beat and reduce it to mud, which, in case of dry weather, will become baked and dried, so as to close the surface and obstruct the action of the air; this, as before explained, will obstruct the capillary attraction, and the plant will be starved. But if holes be made, as before directed, to the depth of the roots, and water be poured into them; or if water be poured so gently on the surface as not to beat and reduce the soil to mud and close it, in sufficient quantity to penetrate to the depth of the roots, and the supply be repeated as often as the soil becomes dry, plants may be sustained in as great luxuriance during a great drought, by artificial supplies of water as by regular supplies of rain. It should

also be observed, that one full supply of water will always be more effective than a scanty supply often repeated.

Q. Are there not proper seasons for transplanting the plants as well as sowing the seeds?

A. Succulent and annual plants may be transplanted at almost all seasons of the year. But the best time for planting perennial and herbaceous plants is immediately as they are past ripening their seeds, or in the spring of the year, just before they begin to shoot. Shrubs and trees that shed their leaves had better be taken up and removed as soon as their leaves are off, in October or November; if the place in which they are intended to be planted be not ready to receive them, they may be laid on some dry earth, with their roots lightly covered, for a month or two or until they are wanted to be replanted in the place where they are to remain; for as it will require some time for the wounds in the roots to cicatrize, and to prepare for the emission of fresh roots, and as this operation will be best performed when the earth is so lightly placed over them as to admit a free access for the air, the plants will be benefited and time will be saved; and the tree will afterwards establish itself in the earth much more readily, when planted where it is intended to remain, than it would if left to be removed at a later period. Plants and trees may indeed be removed with safety at any time between the falling off of the leaf and the coming forth of the buds in the spring. But evergreen shrubs

and trees thrive best when transplanted just as they are putting out their buds, which is late in the spring, generally, perhaps not until April or May.

Q. In planting fruit and forest trees for the purpose of orchards, &c., where the expense of improving or altering the position and general texture of the soil cannot be afforded, what is the best method of preparing that part of the earth in which their roots are to be placed?

A. In no case must the roots be buried below the bottom of the vegetative earth, whether this be shallow or deep. Most lands are covered with a stratum of vegetable soil of greater or less depth; and as it is this soil which furnishes the most wholesome food, and the roots of trees seldom raise themselves above the level in which they are originally placed, it must be obvious that, when planted below this, they cannot extend their roots, so as to obtain the required supply of food to sustain them; on the contrary, if their food lies deep, as the roots will naturally delve or push themselves downward in search of it, they will soon attain the depth required, however shallow they may originally be planted. When, therefore, the vegetative soil is not of sufficient thickness to cover the roots, the better plan is to raise a hillock of good earth around the trunk of the tree, of sufficient height to cover the roots from three to nine inches, sloping the surface gradually around to the level of the native soil; and until such time as the roots have taken to the native soil, the

space above them should be covered with loose straw or dung.

Q. On transplanting trees and plants, is it not necessary to reduce the branches or trunk, by cutting them back, and shortening them?

A. This is seldom necessary, when the plants and trees are of a proper form or figure, and are removed with care at the proper season of the year; and as the shortening and reducing the trunk and branches is apt to distort and spoil the symmetry of the general form or figure of the tree and the orderly arrangement of the branches, as also to retard fructification, it is better to observe such care in removing and taking up plants, as to do it without injuring the roots; and to take them up sufficiently early in the season to allow them full time to recover and establish themselves, so as to furnish the sap required to sustain the head and branches undiminished. By a due attention to these things, trees of a very large size may be removed, and enabled to establish themselves, so as to produce and sustain a crop of fruit the following season, and to preserve their uniformity of figure unimpaired. But if it be late in the season when trees are taken up, and the roots are so much diminished and injured, that the following season the trees cannot be furnished with sufficient sap to sustain the head and branches, or to prevent the bark and vessels from shrinking and becoming inflexible, it is better to head them back; for as the sap vessels of the branches which form the old head will be incapable of expand-

ing, so as to receive all the sap furnished by the roots, the second season after removal, when the roots are restored, the sap will force its way out and form new branches near the root; the better plan, therefore, in such cases must be, to reduce the head and branches just at the time the buds open, in the spring after planting, and to shorten them to such lengths that the roots may be able to fill and support them.

Q. But are not trees and plants cut down and shortened, both before and after planting, for the avowed purpose of making them grow stronger, and of forwarding fructification?

A. Such is the common practice, but it is evidently in opposition to the laws of nature, as before explained. It also proves that those who undertake to produce such effects by such means are ignorant of their causes.

Q. If these operations, then, are performed in ignorance, the art of pruning, as it is usually conducted, must be inefficient; but is not this part of the art of gardening of the greatest importance?

A. In the general practice of gardening, there is no operation more ignorantly performed than that of pruning; yet no part of the art can be of more importance; and as that will form the next object for our consideration, we must give it due attention. It has been observed, that the growth and productions of flowers and fruits, of each species of plants, are governed and determined by some pecu-

liar instinct, or by particular propensities and habits; consequently, the mode and times of pruning each must be separately explained. We will, therefore, arrange them in the following order:—planting, training, and pruning, the peach, apricot, plum, cherry, pear, apple, grape-vine, fig, &c., and the management of forest trees, &c.

MANAGEMENT OF THE PEACH TREE.

Although the fruit of the peach and nectarine are very different, both in appearance and in flavour, the trees are precisely the same in nature and habits, and require to be managed exactly alike in every respect; therefore, in our explanations, although we speak of the peach tree only, it must be understood that they equally apply to the nectarine.

The peach tree, being a native of a warmer climate than that of England, it requires, in this country, to be sheltered from cold, and to be favoured with the accumulated heat of the sun; for this purpose, and to secure a more certain production of fruit by protecting it against all casualties, it is planted against walls, and under glass; and as the construction of such preservatives is attended with great expense, it is always a desirable object to train the trees in such a manner that they may bear the greatest quantity of fruit in the smallest possible compass. When planting fruit trees, then, we must duly consider our means, and adapt the preservatives to the tree, or the tree to the capacity of the preservatives, as may

be required. To be enabled to do this, it will be necessary to understand the natural capacity of the tree intended to be planted. It has been found by experience, that a peach tree, planted under circumstances generally favourable, will cover from 150 to 200 superficial feet of wall, and annually furnish enough bearing wood, to keep this space duly covered, so as to sustain a good crop of fruit; when planting the peach tree then, we may take this capacity of the tree and of the soil as a criterion to judge by, and to guide us in calculating and determining the preparation and proportions of the soil according to the space intended to be covered by the tree.

Q. Have not the form and materials, and the manner of building and covering a wall, considerable influence in determining the produce of the tree?

A. The most uniformly productive, healthy, and vigorous peach-trees have been found to be those trained against a common brick wall with a flat and even surface, without any coping or projection on the top, to preserve it from the rains or other effects of the weather. This, therefore, should be taken into consideration in building walls or other preservatives for fruit trees.

Q. The wall being provided, what is the best method of preparing the beds or borders in which the trees are to be planted?

A. As before explained, the peach tree cannot endure stagnant water; therefore a close pavement, a cemented floor, or some other impervious foundation

for the bed or border should always be laid, of a sufficient declination to allow superfluous water to drain off from the soil in which such fruit trees are planted, particularly when planted in conservatories. Such an impervious foundation or sub-soil being formed for the vegetative soil to rest upon, the depth of such soil may be easily and properly adjusted to the space intended for a tree to cover; that is, such a superfice or surface of soil may be provided as will be equal to sustain a tree that will cover the space appropriated, with branches. For instance, twelve inches depth of soil will be sufficient on a duly extended surface to enable a tree to cover from 150 to 200 superficial feet of wall; and a soil of six inches depth will be sufficient to support a tree covering 100 superficial feet of wall. But if it be required to limit or confine a tree to a less space, the extent of surface of the soil, or the spread of the roots, must be curtailed and limited, by being placed in a pot or box, as a less depth than six inches of vegetative soil will not be sufficient to enable a tree to produce and maintain a crop of fruit.

Q. But although a tree may grow luxuriantly for a few years in such a shallow soil, will not the soil be soon exhausted, and the tree, as it advances in age, decline for want of sustenance?

A. No; a plant or tree is seldom so much injured in its health or prolificacy by a limitation of its sustenance that is, by a short or limited allowance of carbonaceous matter and water, as it is by an excess

of either of these: and in case of a deficiency or want of food or nutritive matter, fresh and regular supplies can readily be furnished, in a shallow soil, either by dissolving and diluting carbonaceous matter in water, or by spreading a prepared compost over the bed or surface of the border, and leaving it there to be thoroughly decomposed and dissolved, and carried to the roots by the rains, or by artificial supplies of water. In corroboration of the correctness of those principles, it has been remarked by practical men of most extensive observation, that the oldest and most healthy and prolific fruit trees, are those found growing in a shallow soil, on a limestone rock; and that those which grow in deep and wet soils, are irregular and uncertain in their productions, and subject to canker, ulcerating wounds, gum, and other diseases. It must, then, be obvious that, by adopting the principles and the means here explained, the causes of prolificacy will be best established and the causes of sterility removed.

Q. The soil and sub-soil, or bed for the roots being prepared, what is the next object of attention?

A. As the fructification of plants depends also upon the state and condition of the branches, and the surface of trunk, branches, and leaves exposed to the sun and the air, the proper adjustment and arrangement of these must be the next important object for our consideration. Experience proves that fine fruit is seldom produced on very strong or on very weak branches, but generally on branches of

a middle growth; therefore, to render a tree permanently fruitful, it must be necessary to manage and train it in such a manner, that all the sustenance furnished by the roots shall be appropriated to the production of branches of a proper and equal growth, and that these be so arranged as to present the needful surface of leaves to the required influence of the sun and the air. In determining the form and figure of a tree, as few persons are so void of taste as to prefer deformity to symmetry, or, to be indifferent whether their plants and trees exhibit beauty or ugliness in their forms and figures, we may take it for granted that it must be desirable, as far as possible, to blend beauty with prolificacy in training them; which may be done in great perfection. But the raising and training a tree is like the building of a house, or the raising any regular structure; for if the plan be not first arranged and understood, and a proper foundation laid to sustain it, disorder and confusion must pervade the structure, and it can never be rendered durable, commodious, or elegant. Then, as the first stem and branches of a plant must form the foundation of the future tree, before we fix on a plan, or begin to train a plant or tree; we must, first, determine the space it is intended to occupy, and next the form we wish it to assume.

Q. Suppose, then, it be desired to raise and train a peach tree, to cover from 100 to 200 superficial feet of wall, what is the best form for the tree to be trained in?

A. To explain this, it may be necessary to remark, in addition to what has been remarked already, that every plant and tree is appointed by nature to attain a certain comparative height and fill a certain comparative space, before it fructifies: thus, the pear tree is made to grow higher and larger than the apple; the apple tree higher and larger than the plum; the plum, higher and larger than the almond, &c.: and each kind of tree naturally makes an effort to attain the utmost height and bulk of stem or trunk allowed by nature, which is determined by the soil and climate, before it will admit of a division of its sap into such branches as are required for fructification. Then, in determining the height to which plants and trees shall grow, we may consider the objects of nature to be two: the one, to place it above the obstruction of inferior plants, which may grow about it; the other, to afford a certain surface of bark, or such a space of trunk and stem for the sap to pass over and through, as is necessary to prepare that which is required for fructification. As to any obstructions that may arise from inferior plants growing about and overshadowing fruit trees, this may be very easily prevented, even if the branches were to trail on the earth. Then, how to obtain the required surface of bark, or of stem or trunk, within a foot or two of the earth, with a tree that nature has appointed to grow eight or ten feet high before it forms its head for

fructification (which is the case with the peach tree), must be the first or grand object in training; and, as has been observed, as the peach tree bears its fruit on shoots of the last year, and when the branches are either too strong or too weak, they will not bear fine fruit, it must be necessary to train this tree in such a manner and form, that its sap shall be so equally divided as to form shoots of a medium growth, and that they be so placed, as uniformly and constantly to cover the same space with fruit branches every successive year. Although the principles and laws of nature, which determine the growth of trees generally, have been already explained, as it will be so difficult to train a peach tree, so as to attain the desired object in any degree bordering on perfection, without a precise observance of those laws, that it may be excusable to repeat them. The sap in all erect growing trees, of which the peach is one, will flow into and through those channels that occupy the most vertical position next the root; and it is not only in this respect evident that the flow of the sap is impelled by a principle directly the opposite to that which impels the flow of water, but, as water will flow over a great height above its level with equal rapidity through a syphon as through a tube of the same size placed in a declining position and leading into an open space below its level,—so will the sap flow through a branch so disposed as to form an inverted syphon, in equal

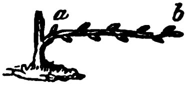
quantity as through the same branch, had it been fixed in a vertical position: that is, if a branch be fixed in a vertical position, thus the strongest shoot will form at the point bud, *a*; so also if it be fixed

thus

or thus

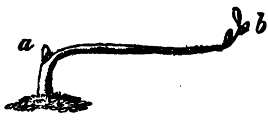
But if a branch be fixed in a horizontal position,

thus



the strongest shoot will be produced in the most vertical bud nearest the base *a*, and the point bud, *b*, will form the weakest shoot: it must, then, be obvious that if it be desired to train the branches in a horizontal position, and still to extend them as much as possible in length, the point of the branch, *b*, must be turned up

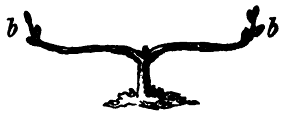
thus.



The point bud, *b*, will then form nearly as strong a shoot as if the branch had been fixed in a vertical position; and the bud at *a*, from its vertical position, and being nearest the root, will take a large share of sap, and form a strong shoot also: if, therefore, it be desired

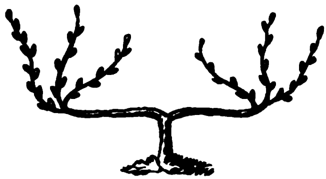
to direct the full supply of the sap to the point bud, *b*, and from that to form the strongest shoot the root will supply, the buds at *a*, with all intervening buds, must be removed; when all intervening buds are removed, as habit soon reconciles a plant to the position of its trunk, its sap will be passed with equal facility through it, when in a depressed position, as when in an erect one, after a year or two. In training fruit trees, then, against walls or other fixtures, we must avail ourselves of this disposition of nature; in the first place, in order to cover a space of wall of 16 feet in length and 12 feet high, and at the same time to provide a surface of trunk of 8 feet from the root for the sap to pass through, to prepare it for fructification (which is required by the peach tree) we must obtain a plant with two equal stems, growing from the same base, of four feet each; for by each taking one-half of the sap supplied, and passing it over four feet, both surfaces together will be equal to one stem of eight feet high: and in order to bring the fruiting part of the tree as near the earth as possible, and to fill the lower part of the wall or frames, we must bend each of the stems down,

thus,

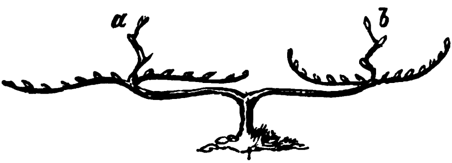


and all the buds being removed but three, at each extremity, *b*, (and it must be remembered that unless this is particularly attended to, conformably

to the tenth law, it will be almost impossible to succeed in training a tree in this manner), those will take the full quantity of sap supplied by the root, and form shoots of proportionate strength, and those shoots, during the summer, may be trained upwards, thus:



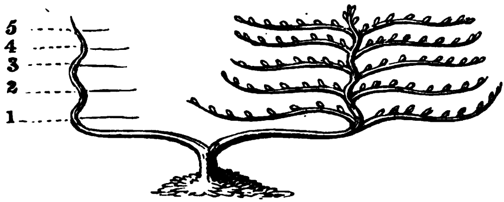
the following winter, the side branches must be brought down to their proper position, to the right and left, thus,



if the horizontal branches are four feet long, or of the full length required to fill the space of sixteen feet allowed, the points of those branches must be laid flat, as on the left hand side, *a*; but if they are required to grow longer, the points must be turned up, as on the right hand side, *b*. The next object must be to manage the centre shoots or stems which are to furnish horizontals so as to cover the upper part of the wall. There are two modes of effecting this; the one is to bend the leading branch in a serpentine

form, as represented at *b*, and form the bends so that they may present a wood bud on the upper side of each, at from four to nine inches apart each bud, which will place the horizontals from nine to eighteen inches apart on each side; all other buds but these being removed, they will be furnished with sufficient sap to form horizontals of due length the following year, and also a centre shoot, to form the stem, to be managed in the same manner, to produce horizontals the following year; and so on every year, until the tree has attained the height of the wall. The other mode of proceeding with the stem, is to train it in an upright direction, and to cut it off, or shorten it (as marked *a* in the last figure) to from nine to eighteen inches every year; rubbing off all the buds, except the three which are best placed at the end to furnish two horizontals and a leader for the following year; this is not only the most simple, but perhaps the most certain mode of providing horizontals of due strength, and at the distances wanted. Indeed this mode of shortening the centre branch must be adopted with all fruit trees except the peach. The peach tree, with care and attention, may be trained on the serpentine plan, so as to place the horizontals with great regularity; when it is thus trained, there is this advantage, the current of the sap being checked in the bends, a larger portion is sent into the horizontals, and the sap is more equally divided, they are thus sustained in greater luxuriance at the lower part of the tree, and sometimes two tiers of horizontals may be obtained in one year. But as almost all other trees

are prone to form their strongest shoots at the ends of the last year's shoots, the bending will not always force out shoots where wanted; in order to secure this, therefore, the leading shoots must be shortened every year, down to the place where it is desired to form the horizontals; and even by this mode of forcing out branches (by shortening); the upright flow of the sap may be checked by bending the leader each year from one side to another, on an inclination of about forty-five degrees, thus:—



Proceeding in this manner, a tree will advance in height only by a tier of horizontals each year, and hence it will appear to fill the upper part of the wall but slowly. But it must be considered, that the time you lose in covering the upper part of the wall, you gain in width on the lower part. It may also appear, on a superficial view, that by extending the branches so long, and rendering them so naked of shoots, for the first year or two, you lose so much time; but it is not so in reality, for by this mode you lose no time in cutting back the stem, as by the usual mode. By the common mode of training, two or more years are lost before it

is attempted to produce bearing wood. Moreover, by laying down the first branches to such lengths, you obtain a space sufficient, the second or third years, to dispose of every inch of wood the tree makes, without crowding it too closely together; and indeed, the means of appropriating to a profitable purpose, all the nutriment extracted from the soil by the tree. From a tree trained in this manner, above seven hundred perfectly ripened peaches have been gathered the fifth year of training, all growing within six feet of the surface of the border. When a tree is full grown, it will exhibit this figure.

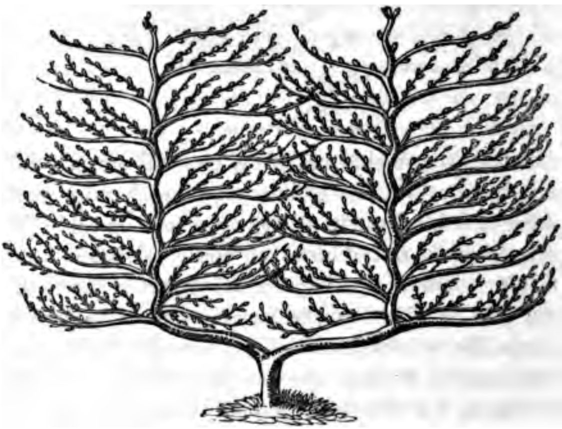


Fig. 10.

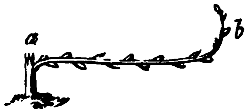
Particular attention must be paid to the rubbing off all shoots as soon as they appear in the spring,

from the front and under sides of the horizontals, as well as from all other parts of the tree, where young wood is not wanted.

Q. The first step, then, must be, to produce trees with two stems of equal growth, of four feet and three or four inches in length: how is this to be done, without cutting back the first year's growth?

A. By a very little extra attention in the nursery trees of two equal stems may be produced the first year, from the budding. This may be done either by inserting the buds opposite each other; or when performing the operation of budding, those buds only should be inserted which have three leaves appended to them, as from such buds, three shoots will be produced; then, as soon as the buds begin to swell in the spring, the centre shoot should be picked out with the point of a pen-knife; the two lesser shoots will then push out sufficiently strong to form two equal stems; and these, if carefully guarded, will produce a plant of proper growth, the first year, from the budding. But if plants with two equal stems are not to be had, plants with one good stem only may be made to throw out a second stem, without cutting back; by this mode, one stem will appear to be a year behind the other in growth, but as the division of sap will be equal; in a few years the youngest will attain the size of the other, and, in the end, both stems will be equal in their appearance and in their produce. The mode is to bend down the single stem, in the same position it would have been placed

in, if it had been joined to its fellow, thus.



The consequence of this bending will be to place the bud at *a* in the most vertical position nearest the root; and hence, this bud will throw out a shoot, and form a branch, that will, either the first or second year, attain the full length required to be laid down, which is four feet three or four inches; and this being laid down in the same position as the first branch, the sap will afterwards be equally divided between them. All the buds that push out between the one at *a*, and the three above the bend at *b*, of course must be rubbed off. This mode of obtaining a second stem is indeed preferable to that of cutting back a plant for the purpose; because it is difficult, by cutting back, to produce two stems of equal growth; for in this case the uppermost bud will generally take the lead, and grow more luxuriantly or obtain a larger share of sap than the other: and when this is the case, there are no means of making them afterwards grow equal—for one branch having obtained the ascendency, it will maintain it always after. It sometimes happens in the nursery, that one of the side shoots of the bud inserted will be destroyed, and the other side shoot, and the centre one grow and form two branches in this case, the side shoot will be weak, and the centre one strong, and when this occurs, the side shoot can never be made to grow equal to the centre shoot, and to form a tree of two equal sides; this, therefore, should not be attempted,

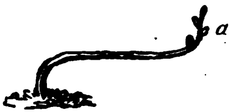
but the weak branch should be cut off, and the other treated as a single stem, as above explained.

Q. Is there no mode of training the peach tree from one stem, to cover the same space of wall.

A. Yes; but not of so dividing the sap as to cover every part of a wall or trellise so equally and effectually with fruit. If, on planting, the tree be cut back to three buds, as in the annexed figure, and the shoots formed by these buds in the summer suffered to grow to their full length, and the winter following fixed thus.

the centre shoot being shortened, to carry on or form the tree, leaving three buds to form two horizontals, and a centre stem the following and every succeeding year, the wall may be covered to any distance the tree is equal to; but it will be difficult to prevent the horizontals near the centre of the tree from becoming naked of bearing wood, because the sap cannot pass through a sufficient space of bark to prepare it for fructification, until it is a great distance from the trunk. But this defect may in a great measure be remedied, if, instead of being cut back to make it throw out branches to form the tree from a short stem, a stem

of four or five feet be bent down thus; and if all the buds, as they push out, be rubbed off, except the three



at the end, those may be trained up in the same manner as if the stem had been cut back or shortened, and afterwards the stem or centre may be treated in the same manner as the one that is cut back; the difference will then be, that the centre of the tree will be formed four feet on one side of the root, instead of being immediately over it; but as the sap will thus have a space of four feet of bark to pass, the tree will produce its bearing wood in greater abundance near the stem and fill the wall more equally with fruit.

Q. When trees are trained in the orderly manner, as here represented; if the branches are worn out, or from any casual injury destroyed or injured, so as to require to be removed and renewed, how are we to proceed?

A. As when trees are trained after the old fashion. It will require time and patience; but as from the peculiar position of the branches, the sap will always continue to flow into the channels that offer the most vertical course, the buds will push out and form branches in the proper position to fill the space that has been left vacant to cover it in the same form, in due course of time; or as before observed, the sap being always inclined

to push out at the most vertical channels that present themselves; if any branch be cut back to the most vertical point, a shoot will be produced at this point, and as this will obtain the share of sap due to that part which is lost, it will soon make good the loss. But if no bud either does present itself, or is likely to do so at the place where one is wanted; a bud, inserted at midsummer, will form a shoot the following year; or a branch may be made to grow from the place by grafting by approach. As the peach tree bears its fruit on branches of the last year's growth, the spaces between the horizontals must be annually filled with such wood; and as the position of the branches will always favour the breaking out of buds, and the forming of young shoots from the upper side of the horizontals and near their bases; if all the buds which push out, except those that grow in the proper places on the upper sides of the horizontals, be rubbed off, those which are left will form strong branches; and if those branches at the winter pruning be laid in a declining position, as shown in figure 10, there will seldom be a want of bearing wood. Again, as by rubbing off all wood buds but those which push out where they are wanted, no shoots will be formed but in their proper places; no other pruning will be required but cutting away the worn out branches after they have borne their fruit, and fixing the young or succeeding branches in their proper places, to fill the allotted spaces with fruit. The old bearers

may be cut out immediately as they are divested of their fruit, whether they are deprived of it by any casualty, either immediately after their bloom, or at other periods of their growth, or when the fruit is ripe; and as there is less danger of injury by cutting out wood in the summer or during the growth of the branches, than in the winter after the leaves are off by cutting out the old bearers and useless wood early, the succeeding branches will be better sustained, ripened, and prepared, for the following year. But if a tree be found to grow too luxuriantly to wood to fructify, or to produce more branches and of greater lengths than are required to fill up the spaces between the horizontals; a sufficiency of young shoots may be suffered to remain during the summer, to consume the redundant sap, which shoots may be cut away in the autumn or winter; at this time also such branches as are too long to be well trained in, may be shortened, but not otherwise.

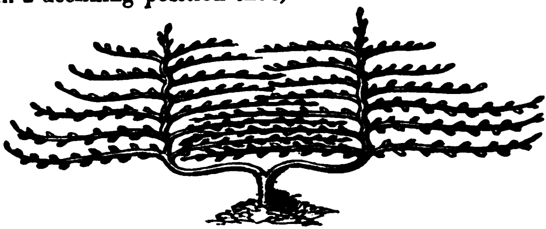
Q. Will not cutting the trees whilst the leaf is on, or when they are growing, expose them to injuries from bleeding, &c.?

A. No; none of the stone fruit trees will bleed at the parts where branches are removed or cut off, nor will those of apples or pears; but if they are wounded when in an unhealthy state in the winter, they will often canker or gum in the spring, and putrefy and mortify; the less therefore trees are handled or disturbed in winter the better.

Q. Is this plan of training as well adapted for any other kinds of fruit trees, as for the peach?

A. Yes; for all erect growing trees, as it equally admits the full flow of sap, and divides the sap more equally in the formation of those branches that are the best adapted to fructification; it also places them at such distances as will allow them to grow without crowding. As, too, it enables a tree to expose the greatest surface of leaves to the light, it enables it to bring its blossoms, seeds, and fruits to the greatest perfection. But as pears, plums, apricots, cherries and apples, bear their fruit on wood of different ages, they require a different mode of management from peaches. Some of those fruits bear their fruit on wood of two years old, some on wood of three years old, and all of them bear good fruit on short spurs for several years successively, no shoot should therefore ever be shortened; but as many shoots as there is room for, should be laid in, and all others cut clean out. As pear trees when grafted on pear stocks are apt to grow to a great size, it is better to train such from one stem; the same may be observed of cherries. But if pears are grafted on quince stocks, they will not grow so much to wood; these therefore answer well, trained with two stems. But, as their branches must never be shortened, their horizontals will require a greater space than four feet each way; however, as it may be difficult to bend stems that are more than four feet long to the proper position, the stems may be bent

and turned up at those distances; but the trees should be planted at twenty-four or more feet apart, as in this case the want of space in the centre may be made up for, by running one horizontal over another, in a declining position thus,



In this manner each horizontal will have eight feet to extend itself, without obstruction; and as pears bear their fruit on short spurs, the horizontals may be trained very close without at all obstructing one another.

Q. Will trees trained after this manner, without ever being cut back and shortened, maintain themselves in health and vigour, for so long a time, and be equally as productive of fruit, as when annually cut back and shortened?

A. It appears, that conformably to the laws of nature, the roots of a tree will continue to extend themselves and increase its supply of nutriment to the body and branches, annually; whether such nutriment be appropriated in the formation of wood in one part of the trees or another, or whether it be appropriated in the formation of wood, or fruit, there is no reason to suppose it can affect the life and

duration of a tree. And as no plant nor tree can bear fruit, until it has attained a certain age, or acquired a surface of branches and leaves proportioned to the food it consumes, fruit must be the consequence of age; but there are no grounds whatever for the supposition, that bearing fruit produces decrepitude in the tree; for it is always found, that the less fruit a tree bears, the more young wood is produced; on the contrary, the more fruit, the less young wood, therefore, whether the nutriment collected, be appropriated to the production of fruit or of wood, it can affect the power and duration of the roots but little. As to the labour and expense attending this mode of training, although it may require more attention and skill than the common mode, the labour is lessened more than half; even that labour which is necessary, is so divided, as to times and seasons, for its exertion, that one man may keep more than double the number of trees in order, than he could do if they were managed and trained in the old way.

Q. But is it not always found, that trees which bear a great deal of fruit, become weak and decrepit?

A. Yes: but the disposition to bear fruit, is the effect of the weakness and age of the tree, or of its inability to extend its growth in wood and branches, brought on by peculiar causes; weakness and decrepitude are not the effect of bearing too much fruit.

Q. When trees are required to fill a high wall,

or a narrow space, is it best to train them with two stems?

A. No; when trees are required to fill such a space, it is best to train them on one stem, thus,

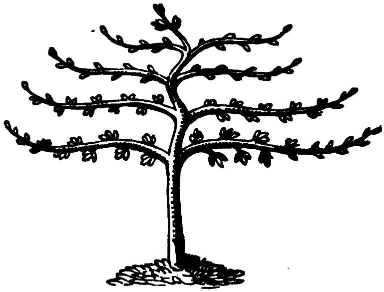
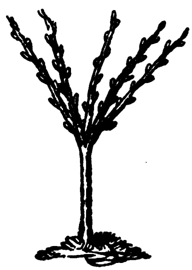


Fig. 15.

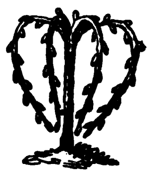
particularly pear trees on pear stocks, cherries plums, apricots, &c. As those trees will not throw out their shoots freely at the bends, but from their horizontal branches at the ends of the year's shoots, the centre branch must be cut back to the part, where it is desired, to form the horizontals, every year; but if the centre branch be bent eight or ten inches out of the perpendicular, first on one side and then on the other, from the base of each tier of horizontals, as marked in the figure, it will be the means of inducing more sap to flow into the horizontals, and thus of sustaining them better and for a greater length of time; and of keeping the lower part of the tree better filled with bearing wood.

Q. As pears, plums, cherries, apples, &c., will grow and ripen in open borders or beds, how are they best trained in such situations?

A. When those fruit trees are intended to form long and flat espaliers, the best plan or form of training them is that by two stems, as shown by fig. 10; or from one stem, as shown by fig. 15. But if it be desired to train them so as to fill a circular space like bushes, they are best trained with their branches reversed, as by this mode they are not only brought to bear a great deal of fruit in a small compass, but are confined and protected against injury from high winds without stakes, which saves a great deal of trouble and expense. To follow this plan, plants must be obtained to furnish one upright stem, of from three to four feet high, and at this height be made to throw out from four to six branches, three or four feet long,

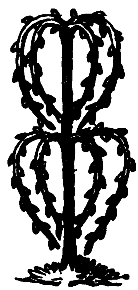


like this figure. At the winter pruning, the branches must be brought down, and fixed to the stem with small willow twigs or twine, thus:



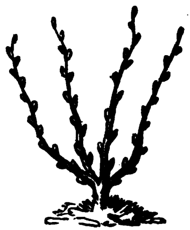
when they are fixed in this manner, the sap will not flow in sufficient quantity down the branches to form wood branches at their ends, but the buds will

more readily form for blossoms and fruit ; the wood shoots will be thrown out on the upper sides of the reversed branches, where they may be permitted to grow their full length during the summer, and in the winter they may either be cut out, or brought down the same as the first branches, either to fill up any vacant space, or to take place of the old branches if cut out. Or, if it be desirable, the stem may be allowed to advance to form another tier of drooping branches for bearers, as in the accompanying figure; indeed on the same principle it may be carried to a greater height. The general management of pruning, &c., of trees trained in this manner must be conducted and regulated by the same principles as when trained to any other shape; all collaterals thrown out where they are not wanted, must be removed as soon as they are discovered; and as the reversed branches or bearers are worn out, they must be cut away, and fresh ones brought down in their places.



The following is another mode of training trees to occupy a small and circular space, by which they may be maintained in a fruitful state for a great length of time, without cutting to waste, and without growing out of the bounds prescribed. Let plants be so managed at, or after, the time of grafting or budding, that they shall form from three to six

branches of as nearly equal size as possible, within about six or eight inches of the earth, as in the accompanying figure; and as soon as the branches are grown from three to five feet long, fix six rods or stakes into the earth for supporting them, in a circle about the root, as in the accompanying figure; the centre dot marking the root and the others the rods.



Each branch is then to be brought down, and being fixed to the rod near its base, the branch is to be carried round in a spiral manner, on such an elevation as will form an inclination of about 15 degrees, and each branch is to be fixed in the same manner, one after another; thus all will move in the same direction, one above the other, like so many cork-screws following in the same course, as shown in the accompanying figure.

As from this position of the branches the point bud of each leader will present the most vertical channel for the sap, the strongest shoot will form there, and thus afford the means of continuing the leaders to a great height, and for a great length of

time, without crossing or obstructing each other, or throwing out useless collaterals ; at the same time, by the depressed position of the leading branches, enough sap will be pushed out on their sides to form and maintain vigorous fruiting spurs. As trees trained in this manner need never exceed the bounds allotted them on a border or bed, a greater number of trees may be planted, and a greater quantity of fruit produced in a given space, than can be, when trained in any other manner. The laws and principles of nature being duly conformed to, this mode of training will require but little other care and labour than rubbing off superfluous shoots and fastening in others as they require it. But as pear and apple trees on free stocks may be found to grow too rude and large after a few years, those will best answer which are grafted on dwarf growing stocks; that is, pears on quince stocks, and apples on paradise stocks. However, to keep dwarf trees from growing too luxuriant and rude, it is a good practice to take them up and replant them every three or four years; if this is done with due care as soon as the leaves are off the trees in the fall of the year, it will not injure them nor prevent them bearing a full crop of fruit the following year.

Q. Is there any better plan of forming and training orchard, or standard trees, than that usually followed?

A. Yes: the common mode of training or forming those trees is as imperfect and inefficient as the com-

mon mode of training and forming wall trees; indeed more so, because they are more exposed to the influence of the wind, as well as to be injured by being loaded with fruit or snow. In the common mode of training and forming standard or orchard fruit trees, the ignorance and folly of nurserymen and gardeners, in attempting to controul and oppose the laws of nature, are more clearly exemplified than in the common mode of training other trees. As before remarked, every subject of nature is formed after the most perfect designs, whilst every plant is induced by instinct or propensity to advance progressively in the most perfect order and regularity, to establish the most systematical and beautiful figures in the arrangement of its branches, leaves, flowers, and fruits; and to acquire the most efficient capacity for propagating its species in the production of seeds and fruits. When, therefore, a full space can be allowed for trees to occupy according to their growth, men will display more wisdom by assisting nature in her progress to attain her ends, particularly when those ends are the same which they desire to obtain, than in opposing her laws and obstructing her progress. All the assistance nature requires to produce plants in perfection and enable them to propagate their species, is the protecting them against casual injuries or such as may be occasioned by animals or the weather, and the supplying and making good any deficiency in the soil, by adding to its mechanical and chemical capacity when required, furnishing nutriment, and otherwise. When an

apple, a pear, a plum, or a cherry-tree, is settled in the earth, furnished with these necessaries and left to nature, it throws all its sap into one stem, and according to the condition of the soil and the influence of the sun, light, and air, with which it is surrounded, it will annually extend itself in height, until it has attained a proportional elevation, when it will proceed to form its head, by throwing out horizontal branches; and as, to produce fructification, it is required that the leaves be duly exposed to the light, and that a surface of trunk, branches, and leaves be produced and sustained, in due proportion to the quantity of sap supplied by the roots; this is found to be admirably provided for by nature, by the collateral or horizontal shoots, which are to form the future limbs and head of the tree, being made to range themselves immediately around the point bud of the leader or stem at the termination of each year's growth; so that, according as the supply of food is great or small, and as the tree is more or less exposed to the influence and action of the sun and air, the stem will be extended more or less in height or length each year. The horizontal branches or limbs, will thus be arranged in tiers at a greater or less distance, according to the condition and situation of the earth they grow in, the nature of the climate, or the supply of food furnished.

Q. Then, according to these principles, a tree that is intended for a standard should not be cut back or shortened during its growth, but the stem and branches should be suffered to grow as nature directs?

Yet, if a tree be thus left to itself, will it not grow too unwieldy and out of bounds, and be too much exposed to the influence of the winds and weather?

A. Quite the contrary. Nature has provided for this: thus, if a tree be permitted to grow unobstructed, and be protected against injury, it will appropriate the whole of its sap to the formation of one leading branch or stem, which, as before observed, will not throw out collateral branches of sufficient strength to form its limbs or head, until it reaches a due height; which height will generally be that which is best adapted to its situation. If, however, the first collateral or horizontal limbs are formed too low on the stem, or too near the earth, these may be removed, and the stem left to take another year's growth, before it be permitted to form a head; and when left to themselves, the horizontals will not spread further than those of a tree that is cut back and trained in the common manner; but they will present a greater and more uniform surface of leaves to the light, and form a more regular arrangement of the horizontal branches or limbs; which, by their uniform growth and exposure, when thus left to nature, will acquire such a form and strength, as will enable them, when loaded with fruit or snow, to bend to the earth without breaking. As, also, from the peculiar position of the branches and the natural course of the sap, they will duly extend themselves without crossing each other, they will consequently require but little use of the

knife at any time. A very slight contemplation of the figure of a tree, thus formed by nature, must convince every person of observation that it possesses all the capacities described as necessary to enable it to produce large and successive crops of fruit, as well as to secure it against casual injuries, in a superior degree to the tree cut back and formed in the usual manner: whilst, at the same time, it exhibits a form perfectly elegant and symmetrical, and such as is altogether calculated to afford much more pleasure to the eye, which is shown by this sketch:—

Q. Are no fruit trees of any description benefited by shortening and cutting them back? When they are suffered to grow, and to retain all their branches, will they not sooner exhaust themselves and the soil they grow in?

A. There are no trees that can be benefited by being cut back or shortened, unless, as before explained, it be the leading stems of those trees trained against walls, where they are apt to be drawn up too long to be left in a state of nature; or to remedy some injury, or to make good

some accidental defects; but there are some creeping plants, such as the vine, and some bushes, such as the currant and the rose bush, that are benefited by cutting and curtailing their branches. As to the notion that plants and trees sooner exhaust the soil or themselves, by being permitted to grow to their full extent, or left to grow without the controul of art, it is palpably erroneous; for as long as the roots grow unobstructed, they will collect the same quantity of food; and whether the branches be cut away, or left to grow, the same quantity of nourishment will be abstracted from the soil. By cutting off some of the branches of a tree, the supply of sap which those would have consumed, if they had been permitted to remain, will be passed into those that are left; which will be made to grow so much more luxuriant, and consequently the same consumption of food will take place. Again, as to a plant exhausting itself, whether it be meant that its powers of production will be diminished by being permitted to retain the full quantity of branches with which it is annually furnished, or that the period of its life will be shortened, the notion is equally erroneous. For whether the branches are cut short, or left their full length, the body or trunk of a tree will continue to increase in size and age; and as the effect of cutting short can only be, to confine the growth of the branches nearer to the body or trunk, and crowd them close together, it must be absurd to suppose that this can

prolong the life of a tree beyond what it would be, if the sap was spread over a more extended surface.

Q. If a large surface of leaves, and a large surface of bark for the sap to pass over, be necessary to produce fructification; whilst cutting back and shortening the branches enlarges the surface of leaves within a given compass; and an increased surface is produced by time or age; how is it that the old trees, which have been constantly cut back and their branches shortened every year, produce but little fruit, and that little not fine?

A. When any production depends upon uncertain supplies of various substances, or upon uncertain protection, and the assistance of those powers whose presence and action is uncertain, (which is the case with the productions of plants and trees,) before we can be enabled to guard against the effect of extremes and establish the medium, we must know what they are. Thus, the branches of a tree may be extremely weak or extremely strong, and fail of bearing fruit from either cause; and as by the operation of pruning, both these extremes may be produced, it must be obvious, that if such an operation be conducted in ignorance of what is an extreme, or of the medium, its effect must be uncertain, and the chances are two to one against its being successful. For instance, if a branch of three feet long be cut back or shortened to a space of six inches containing six buds, those buds will all be forced into branches; these six branches will be confined to a space, not too

great for one; and thus not only will the supply of sap required to sustain one fruitful branch be divided into six, and those rendered too weak, but the leaves which are produced by those branches will be so crowded together, as to deprive each other of the influence of the sun necessary to produce fructification. Further, as no cutting back or shortening the branches will obstruct the flow of the sap, and prevent its flowing into its natural course of the most vertical channels, the sap will be continually forcing out branches from those channels; and as from the space being so limited by cutting those channels will be few in number, the branches produced from them will be too luxuriant to bear fruit; consequently, as a tree thus conducted will be continually forced into one extreme or the other, or into both, it never can produce that quantity of fruit which it would be equal to, if the whole of the sap was employed in the formation of branches of medium growth, or such as are properly placed and adapted, and properly supplied, to bear fruit. Again, as the only bearing branches will be produced from the most luxuriant leaders, and as those leaders are formed on stems projected too far, or on the uppermost branches of the leading limbs of the tree, if these be shortened, the bearing wood must be cut away, and therefore as soon as a tree has attained the full height allowed it, and all the uppermost branches having been cut away, the nutriment allowed and supplied by the roots must be wasted.

Q. When trees have been cut back, and the branches shortened and trained in the common manner, and in consequence they are covered with old and useless wood or grown beyond their proper bounds, what is to be done with them? Can they be reduced to such a form and condition as will enable them to bear good crops of good fruit?

A. In many cases, when the trees are not very old, and the main branches or limbs are not too stubborn to bear bending, these may be brought down and fixed in as horizontal a position as possible; and being divested of all their useless branches, and placed and fixed at such distances as will admit of the young branches they produce being trained in, they will throw out young branches on the upper surfaces of the main branches, and these being trained in due order, and all other shoots being rubbed off as they are pushed out, the trees may soon be made to assume an orderly figure, to furnish the space allotted to them with good bearing wood, and to produce and mature full and successive crops of fruit. When the limbs of a tree are too old and stubborn to admit of being brought into a proper position, the better plan is to cut off all the limbs close to the trunk or head from whence they spring; and as new branches are thrown out, to select and train them in, so as to form a new head and limbs of an orderly and proper figure, conformably to the principles explained.

Q. From the explanations given, it is obvious

that the art of gardening cannot be followed with any degree of certainty of success, unless a knowledge of the science is possessed. But are not the figures to which you recommend trees to be trained, stiff and formal? and cannot the principles be applied to other forms?

A. Certainly the figures are formal, but they are regular, uniform, and orderly: and as order cannot be supported without a due observance of regularity of form, nature is always formal and uniform in all her productions and arrangements. Thus every animal appears to be made up by pairs; it has a pair of eyes, a pair of ears, pairs of legs, &c., &c. On a due examination, it will be found that plants are formed by nature on the same plan of regularity and uniformity. Then may we not conclude, that any person objecting to an arrangement, because it is uniform and orderly, and consequently formal, must be void of good taste, and a proper notion of things? By the old modes of cutting and curtailing plants and trees, every care is taken to give a formal appearance, by confining the outlines of the figure within certain bounds: the effect of this is not only superficial and temporary, but there is no permanent regulation or arrangement; no uniformity of effect is produced, and no harmony in action or procedure; consequently, the figures or forms thus produced, must always be unpleasant to persons of refined minds and a pure taste, and the trees uncertain in their productions. By attend-

ing to the principles that have been explained, no doubt trees may be trained with good effect in a greater variety of forms than are here described, and a great improvement may be made in the results of training trees in the old mode; but it is impossible to produce that equality in the distribution of the sap, and in the growth of the branches, and that exposure of leaves to the light, by the adoption of any other forms than those here recommended; consequently, it is impossible, by any other means, to produce and maintain trees in such a state of health, vigour and and prolificacy. Persons undoubtedly may, and do, indulge their fancies by training trees in various ways, but they cannot alter the laws of nature. And whenever they endeavour to force a tree to assume a form that is opposed to its nature, by cutting away and mangling the branches, they must make a great sacrifice, both of time, and of the nourishment supplied by the soil.

Q. Are there any other plants than those enumerated, that, in the common mode of cultivation, are treated contrary to the principles of science?

A. On a strict examination it will be found that most plants that are cultivated are: at any rate, if the explanations that have been given be duly understood and attended to, they will enable a person to raise every species of plant, and to produce every description of flowers, seeds and fruits, that are commonly cultivated in gardens, in a higher degree of perfection than by the common mode. In

the cultivation of those vegetables, the leaves and stalks of which form the edible part, as well as of those which are planted for their seeds and roots, such as peas, beans, carrots, potatoes, &c., a bad custom prevails of crowding the plants too close together; for, as the produce of seeds, as well as of tubers, is determined by the same laws and principles as determine the fructification and produce of fruit-trees, which is, that the produce shall be in proportion to the extent of the surface of the leaves and branches; and as the surface of these are in due proportion to the food supplied by the roots, it must be obvious that if due space be not allowed, the plants cannot attain the greatest state of prolificacy. In planting any kind of vegetables, we must bear in mind that to enable a plant to attain the greatest state of perfection, it must have a clear space around it, equal to what its leaves and branches will cover, when growing in a state of nature. If this were more particularly observed in growing potatoes, the crop of tubers would be much more abundant and certain in quantity, and much superior in quality, than when grown so close together as they are generally planted. We may also notice a laborious, and consequently expensive, operation, which it is the common practice to perform in the cultivation of potatoes, but which is worse than useless, namely, that of earthing up the potato plants as soon as they appear above the earth: this is done with the view of increasing the quantity of potatoes, but it

does not and cannot produce this effect. For in the first place, a potato planted an inch only under the surface of the soil, will produce a much greater number of potatoes than one planted a foot deep. No doubt, when so near the surface, the tubers will be small; and when planted deep, they will be large, although probably the weight of tubers will be much the same. But as neither very small nor very large potatoes are desirable, and those which are of a moderate size are best adapted to all purposes as food, that plan must be the best which will produce the largest crop of good sized potatoes; such is that of planting the potatoes from six to eight inches deep, at such distances as the green will cover, without one plant touching another, and never to earth up the plants, but keep the ground clear from weeds by flat hoeing only. We may also notice a very erroneous practice that prevails in the common mode of growing cucumbers and melons. It is supposed that those plants derive great benefit from the nourishment supplied by putrescent dung; this therefore is always laid under the earth in which they are planted. But the fact is, neither the cucumber nor the melon plant can endure putrescent matter, but they are always more or less injured and diseased, and their fruit is made to perish by it. No doubt those plants grow most luxuriantly in a soil replete with carbonaceous matter, and in such a soil produce the largest fruit; but to sustain the plants in health and prolificacy, the soil should be free from putrefying matter; that

is, the carbonaceous matter should be thoroughly purified by age and exposure. When cucumbers and melons are grown in such a soil, without any dung under it, they will be found much more productive, and the fruit much more perfect and of finer flavour.

Q. But is not a high degree of heat necessary to sustain the melon and cucumber plants in health and vigour? and if so, how can it be produced by better means than by dung?

A. Certainly those plants require a high degree of heat to enable them to bring their fruit to maturity; and perhaps there is no better, at any rate, no more economical mode of producing the required heat, than by dung; but an artificial supply of bottom heat is only necessary, previously to the month of May; after the month of April, melons and cucumbers planted in the soil without any dung or bottom heat, but covered with glass, do much better than with dung or bottom heat. When, too, bottom heat is to be produced by dung, if a covering of slates or boards be placed on the dung, or such a division made between the dung and the soil, that the roots shall not penetrate to the dung, nor the effluvia of the dung penetrate to the roots, the plants will grow much more healthy, and prove more fruitful.

Q. Is the common mode of applying heat in hot beds and conservatories conducted on correct principles?

A. No: it is in general established and conducted

on wrong principles. The mode of creating and applying heat is founded more on empiricism than science; as before observed, after the month of April bottom heat does more harm than good. When the heat of the sun is concentrated, and preserved from being dissipated and carried away by the winds, by the protection afforded by glass, the soil will acquire as great a degree of heat as is required to maintain plants in health and vigour; when plants are forced beyond this, they are neither the most beautiful in appearance, nor the most fertile in their productions. As we have before observed, all attempts to make nature more perfect, must be grounded in ignorant presumption; perfection can only be attained by aiding and assisting nature, and protecting her operations against casual obstructions. Thus, in growing tropical plants, the best mode of ensuring success must be that which produces, in the most complete manner, the effects of a tropical climate. Now, however great the heat may be during the day, in any climate, it must be much lower during the night; therefore, as the usual practice of conveying heat through the soil, or from the bottom, must make it nearly as great during the night as during the day-time, it must be unnatural; and plants grown under this treatment can neither be so beautiful nor so fruitful, as when treated more conformably to nature. Again, plants, when growing in the open air, whether in a hot or a cold climate, are exposed to a constant

change or circulation of air: it may therefore be concluded, that a constant supply of fresh air, is necessary to support them in health and vigour; this they cannot have by the usual mode of heating houses, otherwise than by admitting currents of cold air; and as the plants, in a tropical or hot climate, are not naturally exposed to the sudden and abrupt changes of hot and cold air, they are not formed to endure it, but must be injured by it. Further: when air is confined in a vessel or room, the hottest air always rises to and occupies the top or uppermost part of such vessel or room; it must therefore follow, that when the air within a room or vessel is heated, and there is no regular exit for it, the air at the upper part must always be much warmer than that at the bottom; consequently, the uppermost part of a plant, placed in such a room, will grow faster than at the lower part. Hence it is found that plants in hot-houses and conservatories are drawn up unnaturally tall and slender; and such plants will not fructify nor ripen their fruit, until they attain a place near the glass.

Q. Is there any mode of heating houses, so as to produce effects more conformable to nature?

A. There are various methods of effecting such purposes. But as to describe them all would not only require a larger volume than the present, and as the author is about establishing a mode which he expects will excel all the different modes in present use, he defers any further observations on this

part of horticulture until he has made the necessary demonstrations.

In concluding these explanations of the principles and modes of managing Fruit Trees and producing Fruit, we may add a piece of advice as to the best mode of obtaining pears and apples in perfection, which is, to gather them from the trees as soon as they have attained their full growth or size, and never to permit them to grow quite ripe on the trees; and, when gathered, to place them in a dry basket, or on a dry shelf, to ripen. When treated in this manner, pears and apples will not only attain a much richer and more vinous flavour, but will keep longer and better than when left on the trees till they are thoroughly ripe. Pears thus managed will not grow sleepy or rotten at the core, nor will apples so soon grow sandy or mellow.

OF THE FIG.

Q. Does the fig-tree require any particular mode of training or management to render it productive?

A. Yes: and for want of attending to the peculiar nature and habits of the fig tree a great diversity of opinion has arisen as to the proper mode of managing it. Thus one party state that the fig-tree never prospers so well as when the roots are constantly surrounded with water: another, that under such circumstances the tree never thrives. The fact is, this difference in opinion arises from the difference

between stagnant water and a constant supply of fresh water, or water that is constantly in motion, not being understood or considered. The fig-tree cannot endure stagnant water, nor putrefying matter about its roots; consequently the fig-tree never prospers better in any soil or situation than in a calcareous soil, and in a soil so situated as to be constantly supplied with fresh water by capillary attraction Such being the case, the fig-tree very much resembles the grape-vine, and when planting it, the same kind of soil and the same kind of sub-soil or foundation should be prepared for it. As the fig-tree cannot endure putrescent matter, the best food for it is a solution of carbonaceous matter with lime and potash.

Q. Is any particular mode of training or pruning necessary to be observed in managing the fig-tree?

A. Yes: the fig-tree bears its fruit on wood of the same year's growth, and, unlike most other trees, it produces two crops of fruit in a year; that is to say, one crop of fruit is produced on the spring shoots, and one crop on the midsummer shoots; but as this tree is a native of a warmer climate than England, the second crop of fruit seldom ripens the same year in this country, unless it be protected from the frost and cold winds during the winter; but if this be done, the fruit produced by the midsummer shoots will ripen the following summer, much earlier than the spring fruit; and although such fruit will not attain the size of the spring fruit, it will be fully equal, if not superior, in flavour. It follows

then, that the fig-tree should be trained so that it may not be necessary to shorten nor cut out any of its branches; for as the fruit is produced on the young shoots, if these are cut away, no fruit can be produced until more young shoots are produced. The fig-tree is an erect growing plant, and its branches are always inclined to grow most luxuriantly in an upright position; but as the most luxuriant branches are not always the most fruitful, the best plan of training the tree must be that of fixing its leading branches in a drooping horizontal position; and as when placed in this position, young shoots will spring from their upper sides, the horizontals should be placed at such distances, one from the other, as will admit of those collateral shoots being trained in as bearers between them; the sap being thus divided, the tree will be furnished with shoots of such moderate growth as are most prolific, and these being trained one over the other in the same inclined position, the tree may be extended to a great distance, without their crossing or shading one another. Thus—

Q. If the second crop, or autumn figs, can be pre-

served through the winter, how is it best done without glass?

A. A simple, neat, and effectual protection may be provided by wrapping the young shoots in brown paper, or by nailing brown paper close over them, when fixed against a wall; this should be done just before the frosts commence in the winter, and the paper should be permitted to remain on until the frosts are past in the spring, or until the middle or the end of April.

Q. What are the indications of stagnant water, or of putrescent matter, about the roots?

A. Although the tree appears to grow luxuriantly, and the fruit to swell, they turn yellow, and drop off at different stages of their growth before attaining maturity.

Q. And what are the indications of a want of food and water?

A. The tree grows but little, the shoots are thin, the fruit are small, and do not swell, but dry up and fall off.

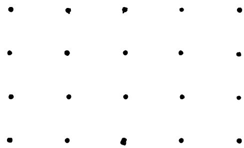
OF THE STRAWBERRY.

Q. Is there any particular mode of cultivating the strawberry, so as to obtain it in perfection?

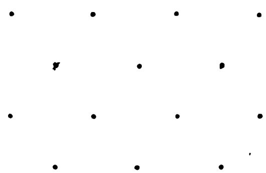
A. By an imperfect mode of management, the strawberry, like other fruit, often falls very short of perfection in flavour, beauty, and quantity. The

growth and production of the strawberry plant, like all other plants, is determined by the ninth law, as before explained; therefore, if the plants are not allowed a sufficient space between each other, the fruit will not be produced in quantity, nor brought to maturity. To regulate and keep the plants within this space, there are two modes of management; the one is, when planting, to place the plants at proper distances from each other, and leave the suckers to grow until the blossoms appear in the spring; and before they begin to blow, to cut out all the plants that have no blossom-buds, leaving the rest at the proper distance one from another; that is, so far apart, that the leaves of one plant may not touch another, which in general will be about nine inches. By pursuing this mode of management, as the first plants produced by the suckers will generally prove fruitful, enough of those will always be found to make good the loss of those old plants which fail: thus, the bed may be kept constantly filled with young and vigorous plants for a great length of time; and sufficient space being allowed between the plants to admit of the full influence of the sun and the air, not only the greatest quantity, but the finest quality of fruit may be obtained. The other plan is to cut off the suckers in the fall of the year, leaving the same plants to bear the fruit, and taking care to keep the ground clear between them. When beds are formed for the plants to be managed in this manner, in

order to obtain the largest crops of fruit the first and second years, the best mode is, to place the plants about nine inches apart, in lines and opposite to each other in squares, as in the accompanying figure, where they may remain, to produce fruit the two first years, cutting away the suckers and weeds in the autumn ; in



the autumn of the second year, as soon as the fruit has been gathered, you should cut away every alternate plant, when they will be left thus : each plant being then 18 inches apart, the suckers being cut away, and the earth



stirred up and cleared of weeds every year in the autumn, the same plants will increase in size, and produce every year successively for four or five years ; and if occasionally supplied with nutriment, will produce the finest fruit. But as plants treated in this manner will not bear well for more than four or five years at most, fresh beds must be formed every three or four years.

Q. What affords the best nutriment for strawberries ? and what is the best mode of supplying it ?

A. It may be supplied in a liquid state, or by spreading carbonaceous matter over the surface of the bed at the autumn dressing; the best preparation is rotten dung, with potash, either in solution or substance. But it will be necessary to observe, that although the strawberry will thrive in almost every soil and situation, it will not prove so fruitful in a soil where the carbonaceous matter is of a great depth: for thus circumstanced, the plants grow more to leaf and suckers than to fruit; therefore, when preparing beds for strawberries, on their first planting, or when dressing them, dung should never be dug in and buried; but if dung be spread over the surface, and be there suffered to remain, too great a quantity cannot well be supplied.

Q. May all kinds of strawberries be managed by both or either of those two modes?

A. Yes; but there is one variety which is very peculiar in its nature; and for want of duly understanding this, it is seldom managed so as to obtain a crop of fruit in any thing like the quantity produced by the other kinds of strawberries; yet, when properly managed, it is the most prolific of any. This variety is the old hautboy, a fruit very different from any other, in colour, form, and flavour. Its colour is a purple next the sun, and generally covered with a fine mealy bloom: its form is globular, a little flat on the top, and its flavour very rich and perfumed.

By those whose taste it suits, no other strawberry is thought comparable to it. The peculiarity of this strawberry is, that two distinct plants are produced from the seeds of the same fruit, the one continually barren, the other prolific; and as the barren plant is more luxuriant in its growth, and more early in its production of suckers, these generally spread, and occupy the bed, to the exclusion of the prolific ones; consequently when permitted to grow promiscuously together, there is seldom to be found more than one prolific plant to twenty of the barren plants.

Q. But cannot the barren plants be distinguished and removed?

A. Yes; but two opinions exist, which have hitherto prevented this: the one is, that the plants which are barren one year, produce fruit the next — the other, that the barren plant is the male plant, whose presence is necessary to mature the fruit of the female plant. But the first opinion is clearly founded in ignorance, as neither the barren plant nor its suckers ever become prolific; the second opinion is at best dubious; for the blossoms of the female plant appear to be duly formed to mature its own fruit, being furnished with stamens and anthers, and it does ripen its fruit in the absence of the barren blossoms. Yet it has been stated by men of practical observation, that, when the blossoms of the barren plant are present, the fruit of the

prolific plant ripens in greater quantity and perfection; perhaps, therefore, the better plan is to leave a few barren plants at intervals among the other plants, taking care to prevent their increase by destroying and rooting out the suckers. The difference in the formation of the blossoms of the two plants is easily seen. In the blossoms of the barren plant, the stamens are long, and the anthers spread full and wide over the stigma, or false fruit, which is very small: whereas on the blossoms of the prolific plant, the stamens are very short, and the anthers placed upon them are so close round the edge of the stigma or embryo fruit as scarcely to be perceived, and the embryo fruit is full and prominent. The difference in the blossoms of the two plants is clearly perceptible, and therefore the best season for selecting and taking out the superfluous barren plants is when they are in bloom.

OF THE CURRANT, GOOSEBERRY, AND RASPBERRY.

Q. Is not the usual mode of managing the currant, the gooseberry, and the raspberry, the best that can be adopted?

A. No—as regards the training and pruning. By a little care and attention, these trees or bushes may be made to assume a more regular and handsome

figure, and, at the same time, be rendered more productive than by the common mode of pruning.

Q. How is this to be done?

A. In planting the cuttings of currants and gooseberries, it should be so managed, that but one shoot should be permitted to grow from the root; this should be fastened up in a perpendicular position, and not shortened, so as to form one stem only, leaving the horizontal branches that will spring from its sides all around it, to form the bearers. If the horizontals from the currant grow more than nine inches in length the first year, they must be cut back to those lengths; but the horizontals of the gooseberries must be permitted to grow their full length, and not be cut back, nor shortened. The currant-bush will then resemble fig. 1, and the gooseberry fig. 2.

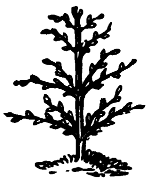


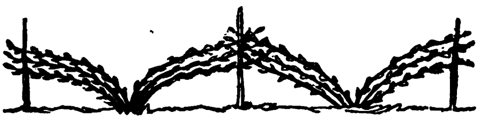
Fig. 1.

Fig. 2.

The collateral shoots from the horizontals of the currant must be constantly cut back, to a space of about an inch only; but the leading branch of the horizontal must be left from six to twelve inches.

The collaterals, on the horizontals of the gooseberry, must be cut clean out, as the horizontals will bear fruit enough; and the leading shoots of the horizontals may be left to grow their full length. Those gooseberries which grow drooping, or too luxuriantly to sustain themselves, or extend beyond the space allowed for them, may be trained round a circle of stakes, in the same manner as directed for dwarf apples, pears, &c., as represented at page 237.

The raspberry bears its fruit upon shoots or stems, annually produced from the roots: that is, the stem that is produced one year, bears the fruit the next, and then dies, back to the root, where it must be cut off. In training, therefore, the stems that bear the fruit, should be placed so as to be duly exposed to the sun and the air, and not to obstruct or be overshadowed by the young stems that spring from the root to produce fruit the following year. It is to be done thus:—



By this mode of training, it must be obvious there will be full room both for the shoots which rise from the root to form stems, and for those which rise from the stems to bear fruit, without their obstructing each other.

Q. What soils are best adapted to these fruits?

A. They are all naturally voracious plants, and thrive best in a sandy soil replete with mould or rotten dung. Indeed, as these fruits, now in general cultivation, have been raised from seeds for several generations, grown in soils luxuriantly supplied with dung, they cannot be grown in perfection without such supply being constantly furnished.

ON THE CULTIVATION OF THE VINE.

Q. Will the vine flourish equally well in all kinds of soil?

A. Although the vine appears to grow well in almost every description of soil, it is never fruitful in a wet, or close and retentive soil; consequently, whenever vines are planted with the view of obtaining plentiful crops of the finest fruit, the bed or border should always be properly prepared, and protected from an excess of water, particularly from stagnant water.

Q. What is the best mode of preparing a bed or border for vines?

A. The first object must be to provide such a subsoil or bottom as will be impervious to the roots and prevent them striking deep, and such as will throw off all superfluous water; this may be done, either by beating stiff clay close together and forming the surface on an inclined plane, terminating at the lower edge with a drain; or, which is much better, by form-

ing a floor of lime and sand or cement, or by laying down a pavement of brick or stone in the same form, and then covering it with from six to twelve inches of soil; which soil should be formed of two-thirds of calcareous sand (or, if this cannot be obtained, old brick and mortar rubbish and coal-ashes broken small and fine, will answer the purpose,) and one-third of mould or thoroughly rotten dung, which, in the language of chemistry, is hydrocarbonate, well mixed together; over this may be placed three inches of the common soil of a garden, or, which is better, loose gravel.

Q. Will vines grow as well under a covering of gravel as under a rich soil? Will they not need supplies of nourishment? If so, how can this be supplied?

A. Vines always grow best, and bear best, when the surface of the soil in which the roots are bedded are covered with gravel, as in this case evaporation and capillary attraction are regularly sustained; when the vines want nourishment it may be supplied by solutions of blood, or of rotten dung and potash, in the manner before described.

Q. What extent of border or bed thus covered will be required?

A. This must depend upon circumstances; as the root of the vine will extend itself as far as the branches, the larger the surface of the bed or border allowed, the more luxuriant and fruitful will the vine be. When vines are to be trained within a house for

forcing, they answer best when the roots are also placed within the house; for this purpose the best plan is to form the full extent of the floor for a bed for the roots, in the manner before described.

Q. What are the advantages resulting from this mode of planting vines within the house?

A. Whenever the buds are forced by artificial heat, the roots will also be forced by the same heat; the whole of the buds will then be fully supplied with sap, will consequently break with greater regularity, and produce a greater abundance of fruit; and as the fruit will thus obtain a more equal and abundant and regular supply of sap, it will be much finer.

Q. But when vines are planted within the house, will they not be exposed to injury for want of water?

A. Yes; but water must be supplied as often as wanted. When the surface of the floor of the house is covered with loose gravel, this is at all times easily done, without creating any litter or inconvenience.

Q. Is water to be supplied periodically? or how are we to know when water is wanted?

A. As vines are more likely to be injured by too much water than by too little, very little attention will prevent the occurrence of injury for want of water; which will be plainly indicated by a drooping of the young leaves, and tips of the branches. Whenever this appears, water should be given in sufficient quantity to penetrate to the depth of the soil. When thus supplied, it will not require to be

often repeated; perhaps not more than once in eight or ten days when the vines are growing, and not so often when they are at rest.

Q. How is it to be known when solutions of carbonaceous matter are wanted?

A. The vine is a voracious plant, and it is difficult to feed it too highly, or to furnish it with too much carbonaceous matter, provided water is not given in excess, or permitted to stagnate; if, too, a vine has room sufficient to expose its surface of leaves, it cannot well grow too luxuriant; when, therefore, the vine does not grow strong and vigorous, solutions of blood, or rotten dung, with pot-ash, may be supplied; and if the branches grow luxuriantly, but are green and succulent, and do not grow hard and ripen well, a solution of pot-ash will remedy the defect.

Q. The bed or border then being provided, what is the best method of obtaining plants?

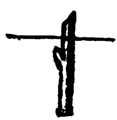
A. Whenever the roots of a vine are curtailed and injured in transplanting, it will not recover itself to bear fruit in less than three years. In providing plants, therefore, where the saving of time is an object, the better plan is to raise the plants from cuttings in pots, as the plants can then be shifted and transplanted without curtailing the roots, or they may be raised by layers in pots; and when this is properly done, the plants will produce fruit the following year. For this purpose either of the following modes may be adopted. At the time of pruning, take a shoot growing from the end of a

branch, the more vigorous the better; and drawing it up through the hole at the bottom of a pot, thus—fill the pot with a sandy soil, and keep it saturated with water; in three or four weeks, after throwing out its shoots, it will have formed roots; when these appear, which may be known by removing the earth a little, the parent branch should be cut three-fourths through its substance by taking out a notch, and in ten days or a fortnight more it may be cut off entirely and removed, and the plant may be then transplanted where it is intended to grow. If properly managed, the plant will be loaded with fruit the same season, and may be cut off with its fruit on it, and if placed in a dry room the fruit may be thus preserved all the winter, giving water as long as the leaves remain on, but not afterwards; and if transplanted into a proper

soil and situation, it will bear fruit the following season. Another mode, is to take a shoot of the year, about the middle of June or just as the fruit is coming into blossom, bend it down and fix it in a pot, as in the accompanying figure; and, filling the pot with a sandy soil, keep it

saturated with water; in the course of a month or two, it will have thrown out roots, when it may be cut three-fourths through, and, ten days after, severed from the parent branch, and removed and transplanted. When time and circumstances will not admit of plants being obtained in this manner, they may be raised by cuttings from eyes, prepared as follows:—In January or February take a young shoot of the last year, and cut off the eyes with a sharp knife, leaving about half an inch of wood each way, as in the accompanying figure;

then place the eye or cutting in a pot filled with an open sandy soil, about three-fourths of an inch under the surface; cover it with the soil, and keep it supplied with water: if thus prepared, the eyes will form plants in one year, which may be planted out the following autumn, and will bear fruit the following year. Or plants may be raised from cuttings thus:—Take a young shoot and cut it off with a sharp knife in a slanting direction, about an inch above the eye, with an even transverse cut, about two inches below the eye or bud, as in the accompanying figure:



plant this cutting in a pot, if required to be transplanted at some future time, or in the place where it is intended to grow, by plunging it into the earth, deep enough for the slanting end to appear just above the surface, and the bud or eye just under it. If these cuttings are thus planted, and placed under the influence of artificial heat, or in a hot-bed,

they will grow sufficiently vigorous to bear fruit the next season; and if planted in this manner in the natural soil where they are to grow, they will produce fruit in as little time as the strongest plants, whose roots are reduced and injured by the usual mode of taking them up from the natural soil and transplanting them.

Q. A vine being planted, what is the best mode of pruning and training?

A. This must depend upon the situation, and the space to be covered with the vine. But be this as it may, the vine being a creeping plant, its growth and production are regulated and determined by certain and peculiar laws, and it is endowed with powers and properties very different from those of erect-growing trees. Those laws, habits, and propensities, therefore, must be understood and conformed to in pruning and training, to ensure success; they are as follow:—

1. The vine, like all other plants, extends its roots annually; and the roots range as wide and as far under the surface of the earth, as the branches do above it.

2. The vine bears its fruit on branches of the same year, produced from branches of the preceding year.

3. Those branches which are the most vigorous and best ripened, by being most exposed to the light, and to the sun and the air, during their growth, are the most fruitful.

4. In whatever position the branches of a vine may be placed, whether perpendicular, ascending or descending, diagonal or horizontal, or curved and bent in any figure, the strongest shoots and the most vigorous and fruitful branches are formed from the two buds that grow and are well ripened nearest the extremity of a last year's shoot, whether it be a long or a short one.

5. The greatest quantity and finest quality of fruit are always produced by those branches which are ripened at the greatest distance from the roots.

6. The leaves are absolutely essential to prepare the buds at their foot-stalks for fructification, and to mature the fruit.

Such then, being the laws of nature, and the habits and propensities which govern and determine the growth and produce of the vine; if the object be to obtain the largest quantity and finest quality of grapes, in a given space, that plan must be the best which is most conformable to and best sustains those laws, habits, and propensities. The following will be found to be such; they also form the most uniform and orderly system:—

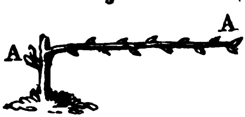
In the first place, in whatever form we may determine to train the vine, supposing the plant to be formed of a single stem, it must, as soon as it is established in the soil and is sufficiently vigorous to produce fruit, be cut back to the point from whence we wish the first leader (meaning the branch that is to produce the bearing branches the

following season) to grow; all other buds being rubbed off but the two nearest the end, those will, conformably to the third law, appropriate all the sap supplied by the roots to the support of those two leaders, which will, in consequence, attain the utmost vigour the root is capable of producing, and having no other branches to overshadow them, will be well ripened. The plant will then have formed the leaders, and assumed the accompanying figure. The stem or trunk, from A to B, of course may be left of that length which is best adapted to the space it is intended to cover with fruit. At the winter pruning these leaders must be shortened; the uppermost one to from three to nine feet, according to its strength and ripeness, and the space it is intended to fill; and the lowest to

Fig. I.

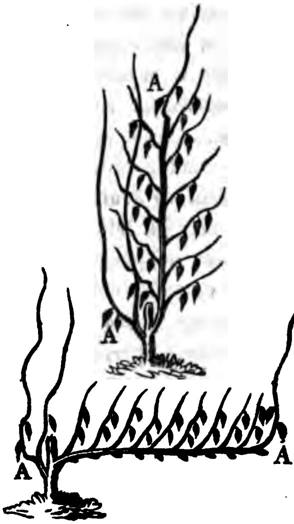
two eyes or buds only, as in figure I.; or if intended to be trained horizontally, it must be fixed in that position, as in figure II. The following summer, according to the second and fourth law,

Fig. II.



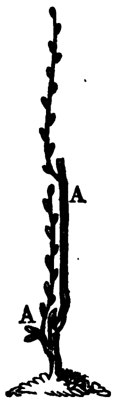
the two buds at the extremities of A and A will form the strong shoots for leaders, and each of the other buds will also throw out shoots, which may be expected to bear from one to three

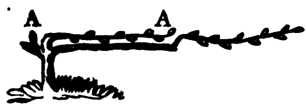
bunches of grapes each. The tree will then be thus formed:



The branches bearing fruit being shortened at the second joint above the fruit, and the leaders from A to A being carried their full length, these leaders will be fully exposed to the light, the sun and the air; according to the third law, they will also be prepared in the best manner for producing bearers the following season, and at the same time be placed in the best possible position to extend the tree, and cover the same space with fruit every year; for

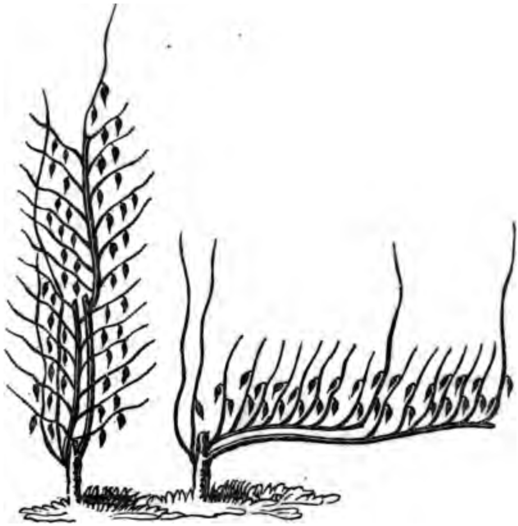
the uppermost leader being shortened to its proper length and fixed in its proper place, and all the bearers, or those branches which produced the fruit, being cut off close to the old wood, the uppermost leader of the lower spur, A, must be shortened to the length of the old leader, A, and fastened close to it; and the other branch shortened to two buds or eyes. The tree will then resemble these figures:





The following summer each of the eyes or buds will throw out branches and fruit, and the buds at the end form strong shoots for leaders, to produce bearers

the following season. The trees will then form these figures :—



Following the same principles and plan the next year, three spaces or lengths will be filled; the next year four; and so on, until the full space is filled. There will always be an extreme end of a shoot to furnish a new leader to cover the old one, from whence all the bearers are cut, and to extend the tree. When the first or main branch has reached the full length allowed it, and ripened its fruit, it may be cut off at its base close to the

trunk. This operation being performed annually, no wood will be left on the trunk beyond a certain age to encumber the root, or uselessly to fill up the training space.

Q. When the leaders are left so long, as from three to nine feet, will they not become naked from the buds failing to break?

A. Not if the vines are planted so that the root and the trunk and branches are under the same degree or influence of heat. As vines are generally planted, to be ripened under glass, that is, the root in the open air, and the branches in a higher degree of artificial heat: the buds are found to shoot before the root can supply a sufficiency of sap to maintain more than two or three buds or shoots upon a leader; in such cases, therefore, it has been found necessary to shorten the leaders to two or three buds only, or to produce the bearers from spurs left on the old wood; and under such circumstances, this seems to be the best mode of training vines; but as the third, fourth, and fifth laws, will always be found to prevail, it is impossible to raise such large bunches or such fine fruit from spurs upon old wood, as from vigorous young branches.

Q. Then are we to understand, that, although when the vine is placed under natural circumstances, that is, when the root, trunk, and branches, are under the same degree of heat or in the same climate, the greatest quantity and finest quality of fruit is pro-

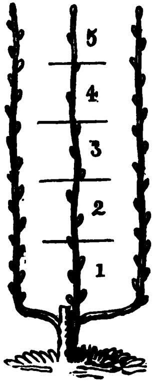
duced from the strongest branches, left at great lengths; but that when in an unnatural state, or the branches in a high degree of heat, and the trunk and root in a low degree of heat, the best plan is to leave spurs for bearers, and that for this purpose, no regular form need be observed?

A. Under those unnatural circumstances, as the root cannot supply more sap than is sufficient to push forth and sustain two or three buds upon a shoot; it is best to shorten the leaders, so as to leave as many spurs or shoots, of one or more eyes or buds only, as will cover the space required with fruit; but this should be done in a regular and orderly manner; for when this mode of training is conducted on a regular system, more fruit, and much finer fruit may be produced, than when the trees are trained without any regard to regularity or order.

Q. What is the most regular plan or form of training by spurs?

A. The same forms may be established in training by spurs, as when the leaders are left of great lengths; the only difference will be, that we proceed with one leader only, without leaving any spur at its base to furnish other leaders, shortening this leader annually to as many buds as the vine will throw out and sustain, whether it be two, three, or more; and instead of cutting the bearers off close to the leader at the winter pruning, we shorten them to one or more eyes or buds, to produce bearers the following season, and so proceed to carry the leaders

in straight and parallel lines, thus—



As by this regular mode of covering the space allotted, the branches will be so divided and disposed, as to admit the full influence of the sun and air, and prevent any waste, by superfluous branches; it must be obvious, that not only will a much more orderly and pleasing appearance be maintained, but the fruit will be sustained in the best possible manner when grown from spurs. The lines between the figures must be supposed to mark the length of the leading stem left, each year.

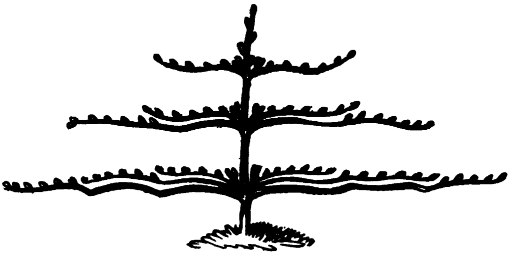
Q. Then a vine may be trained with more than one line, or tier, of leaders and bearers from the same root?

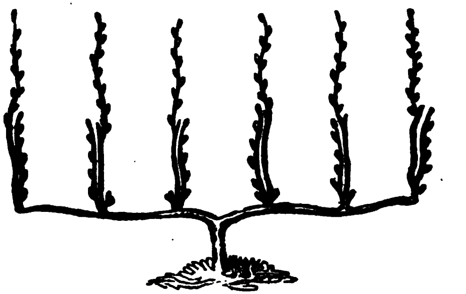
A. Yes; as many perpendicular lines or horizontal tiers of leaders and bearers, may be formed and trained from the same root as may be desired; indeed, where the largest quantity and the finest quality of fruit is the desired object, it may, conformably to the fifth law, be obtained more effectually by covering almost any space, however large, from one root only than from any number of roots.

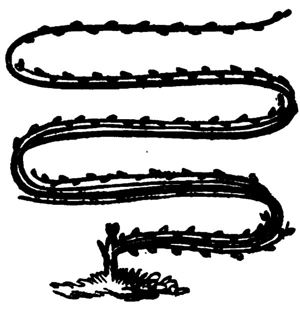
Q. What are the best plans for effecting this?

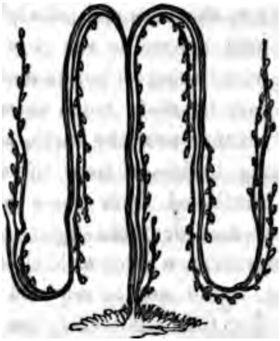
A. The growth of the vine being determined by the fourth law, it may, by observing this, be trained to almost any figure the imagination may suggest;

but the following sketches exhibit the best perhaps that can be adopted.



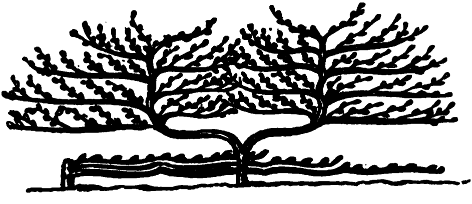






By either of these plans the space may be equally divided, and each division annually and equally covered with fruit.

The plan suggested by Hitt, of growing grapes under peach trees, has been established and for a long time followed by the author, with the most valuable results, as it proves that vines trained with their leaders within a few inches of the earth and the bearers perpendicularly from them, produce much finer grapes, and ripen them earlier by ten days or a fortnight, than when trained even four or five feet above the earth. This plan may easily be understood from the following sketch:—



It is obvious, that, the laws and principles of nature which govern and determine the growth and production of the vine, being as herein described, vines in a vineyard may be made much more productive, trained in this manner near the earth, producing the fruit from young leaders of from three to six feet lengths, and continued from roots planted from twenty to forty feet or more apart, than by any other mode, moreover, a fence or shelter, or body to reflect the heat, would not be required to be raised to a greater height than eighteen inches or two feet; grapes may thus be grown and ripened, at a cheap rate, and to a large extent, in this country.

PART VII.

OF THE PLANTING AND MANAGEMENT OF TIMBER AND FOREST TREES.

Q. Do timber and forest trees require a different management to fruit trees?

A. In many respects they do. From what has been said, it must be obvious that the fructification of trees, and a luxuriant extension of branches and trunk, seldom exist under the same circumstances; therefore, as a large bulk and free growth are requisite to form profitable timber trees, and it is not desirable for these to bear fruit, they must be treated in a manner different from fruit trees. In the first place, as before observed, transplanting will often make a tree fruitful which never was so before, because it will check the luxuriant supply of sap, and by cutting off the tap or downright roots and inducing the throwing out horizontal ones, and thus compelling the roots to collect the food near the surface of the soil, the tree is sustained in a fruitful

and healthy state, because its powers of extension are checked and reduced. Such, then, being the case, if a large bulk of trunk and branches be the object, the downright or tap root must never be cut off, nor the natural efforts of the roots to delve deep into the sub-soil be obstructed: therefore, as has been very judiciously observed by Evelyn—"If you want a large tree, plant a small one;" and the still more certain mode of obtaining such an object would be to plant a seed, and raise a tree from it without transplanting.

Q. Do these principles apply to all kinds of timber and forest trees?

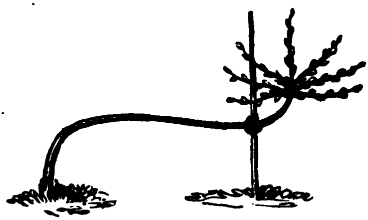
A. Yes: but not perhaps with equal force; as has been explained, every plant and tree is endowed with peculiar powers or habits, adapted to some particular soil and climate: thus, the oak is adapted to a deep soil, and furnished with a carrot or tap root, which it is enabled to push to a great depth; consequently, the deeper the soil in which an oak grows, the larger and finer will be the tree. On the contrary, the elm is adapted to a shallow or surface soil; consequently, as its roots extend horizontally, the elm is found to grow to the largest size when a few feet in depth only of alluvial soil is resting upon a springy gravel. The ash partakes of the habits of both the oak and the elm, and flourishes best in a soil of medium depth. The beech is formed for a deep chalky or calcareous soil; and the fir and the larch for a deep sandy soil, &c. When planting

timber trees, then, as putting the land in a proper state for every kind of tree must be attended with great expense, the better plan is, to select and plant such kinds only as are adapted to the natural soil and situation; for unless those peculiarities are duly observed, success must not be expected.

Q. Then suppose the soil and the different kinds of trees to be determined on and furnished, do they all require the same mode of management, as to training, &c.?

A. The soil being stocked with the proper kinds of trees, and the object of growing them being the same, they will require very little difference, if any, in the management. If tall and straight stems or trunks be desired, the plants should be placed close enough together to shelter each other; as they advance in height, and their heads spread so as to overshadow one another, the plants should be thinned by cutting down, or some of them taken away; and from their commencement, all collateral shoots, or such shoots as grow out of the stem, should be cut away; which is best done in the spring as soon as the buds form shoots of an inch, or less, in length. But if the object be handsome and ornamental trees, to grow independent upon a lawn, the plants, from the beginning, should have ample space allowed for the spread of their branches, and no branches should be cut away. If crooked timber be wanted, this may be obtained, crooked at almost any lengths and to any angle desired, by taking the tree as soon as

its trunk is long enough to form the figure wanted, and bending it down and fixing it in the form which it is desired to make it grow in; taking care to turn up the head and fixing it in a vertical position, thus:



all collaterals that may break out on the trunk must be rubbed off as soon as they make their appearance. Trees treated in this manner will need no fixtures after the first two or three years, as after that time they will make no effort to gain their natural vertical position, but the trunk will regularly expand and grow as luxuriantly as if it had not been bent.

Q. Will not cutting away the collateral branches obstruct the growth of a tree? and cutting back or shortening the stem make it grow stronger?

A. No; agreeable to the eleventh and the thirteenth law, if the collateral branches be removed, the sap which those would otherwise have consumed, is passed up the trunk to the uppermost branch, and that is made stronger, and the height of the tree is thus increased. By the same laws, if the head or leading shoot of the stem be cut back or shortened,

the sap which that would have consumed is diverted into other channels; therefore, although the shape or form of the tree is altered, the capacity and growth of the roots continue the same; and, consequently, by such an operation the constitution of the tree cannot be strengthened or amended. If the stem of a young tree be much injured by being barked or fractured after being transplanted, and be consequently deprived of the quantity of sap required to fill the vessels, so that they shrink and become inflexible, and are thus rendered incapable of secreting and passing up the quantity of sap required for extending the growth of its head, it is better to cut back or shorten the stem, as near the root as may be, and train up the strongest young shoot that is best placed for the purpose of forming a fresh stem. To promote the attainment of this object, all the other shoots, except the one selected, should be removed.

Q. You say the collateral shoots should be rubbed off from the stem, in the spring, as soon as they have grown an inch or less; why is this better than permitting the shoots to grow during the summer, and cutting them out in the winter?

A. Because when the shoots are left to grow, they rob the head and trunk of so much nourishment, and thus retard its increase in height; whilst by rubbing off the buds which break out where they are not wanted in the spring, the formation of knots in the timber is prevented.

Q. Is it a good practice to manure or enrich the soil, when planting timber trees?

A. This must depend on the state of the soil and the object of planting. If it be desired to force the growth of timber trees, a supply of food will furnish the means, as with all other plants and trees; but it must be understood, that timber of rapid growth is neither so strong, nor so durable, as that of slow growth—the more luxuriant the growth of a plant, the larger and more extended will be the tubes which constitute its texture, and the coarser will be the grain of the wood; and as it will hence be more absorbent of moisture, it will more readily rot and decay.

PART VIII.

OF THE LAWS AND PRINCIPLES OF NATURE THAT MORE PARTICULARLY REGARD AGRICULTURE.

Q. Are any of the common operations of agriculture opposed to the laws and principles of nature, as here explained?

A. Yes: those which are called manuring. The practice of supplying manure is, to carry putrescent dung on the land and plough it in immediately; whereas in the course of nature, putrescent animal and vegetable matter is not placed in contact with the roots of plants, but left on the surface of the earth, and after being decomposed and rendered soluble, it is then combined with water and carried to the roots. From what has been said of the nature and effects of putrescent dung when placed in contact with the roots of plants or trees, it must be obvious, that the crops of grain as well as of roots are much influenced by it. When lands are supplied with dung in the common mode, the plants often grow

luxuriantly; but every practical man of observation knows, that plants which run much to green or produce a rich and luxuriant foliage, seldom produce the most in quantity or the finest quality of grain; nor the sweetest herbage, nor the sweetest roots. As before observed, a plant cannot fructify until it has a surface of stalk and leaves proportioned to the food it consumes; this it cannot well obtain, when its food is rank and in excess. Moreover, plants in this state are subject to failure from what is termed blight, and liable to be beaten down by the winds. Any person who will make a fair trial, by laying dung over the surface of the land after it is sown or planted, instead of ploughing it in, will be convinced that this is the best mode of supplying dung to grain crops of every description, as also for the production of roots and green crops; for although the quantity of produce may not be so great as when the dung is buried, the quality will be much superior; such also will be the case with all the cabbage tribe. Any person who will notice the flavour of cabbage, brocoli, kale, turnips, &c., grown in land that has been prepared by the dung being buried, will find it rank, bitter, and nauseous; whereas, when the dung has been laid on the surface, the vegetables are more pleasant in flavour, and more saccharine. It is well known that the greater the quantity of saccharine matter in vegetables, the more nutritive they are to animals; and the quality is generally of more importance than quantity. As before

observed, from not acting in due conformity to the course of nature, great difficulty is found, and a length of time employed, in converting arable land into permanent pasture; but by a due attention to the operations of nature, arable lands may be converted into permanent pasture without difficulty, at a trifling expense and without the loss of a single year's crop.

Q. By what process then is this to be effected?

A. The land must be ploughed and cleaned the same as for a wheat crop, any time between the months of August and November; but if it be too dry to work early in the season, it may, after it is ploughed, be permitted to lie fallow or rough, until the first rains render it sufficiently friable or mellow to work well under the harrow and roller, when it should be sown with proper seeds selected for the purpose; these will then grow and cover the ground, and by May, in the following year, it will be furnished with a sward sufficient for feeding any description of cattle; or, if required, will afford a good crop of hay.

Q. But why is this season better adapted than any other for such purposes?

A. The course pointed out by nature is always best supported and provided for by nature. It is at this season of the year that the seeds of the permanent grasses get ripe, and if left to nature are self-sown; at this time, also, the land is in the best order to receive the seeds, as it is sufficiently wet and warm to vegetate them, and sustain the plants in a

vigorous growth; and during the winter the roots get firm possession of the soil, which enables them to acquire vigour and health sufficient to cover the ground the following spring and summer. A further advantage arises from the destruction of many of the weeds during the winter.

Q. How are the seeds of permanent grasses to be obtained; and what are the best sorts?

A. The seeds of almost all the permanent grasses may at all times be obtained of the seedsmen in London. The sorts may be determined by observing what peculiar natural grasses answer best in the soil and situation where it is intended to establish a permanent pasture.

THE END.

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